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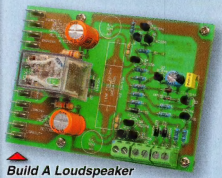

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SILICON CHIP
www.siliconchip.au

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SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Hannanprint, Noble Park, Victoria.

Distribution: Network Distribution Company.

Subscription rates: $97.50 per year in Australia. For overseas rates, see the order form in this issue.

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ISSN 1030-2662
Recommended and maximum price only.

Publisher's Letter

DAB+ radio broadcasting has a long way to go

This month, we have a couple of letters discussing DAB+ and the main one is from Joan Warner, CEO of Commercial Radio Australia, promoting the cause of DAB+ against those who would argue that it has been a disappointment. From my point of view, DAB+ is a disappointment because its sound quality is usually nowhere near as good as it can be. This topic has been raised in our Mailbag pages several times since the introduction of DAB+ and nothing has changed to cause a reassessment of that view.

The basic problem is that most broadcasters have elected to use too low a data bit rate and therefore audio quality is severely compromised.

While this may be of no real consequence for stations that are mainly talkback and sports-oriented, it is pretty poor for stations that mainly broadcast music, whether it is classical, rock, country & western or whatever. Perhaps the worst example is the DAB+ station ABC Classic which broadcasts the same program as ABC Classic FM. Sadly, the sound quality from the FM stereo broadcasts is clearly superior to that from DAB+. This is a pretty poor effort from the national broadcaster.

Furthermore, as bad as it is, sound quality is not the main issue. DAB+ can be an advance for listeners in areas of reasonable signal strength where existing reception from AM or FM broadcasts is noisy and subject to interference. AM radio seems to be particularly subject to interference from digital services such as ADSL and pay TV where there are above-ground cables present and DAB+ can be a revelation by comparison. The fact that there are many extra stations available to listen to is a bonus.

But DAB+ reception in cars or in the canyon-like streets of major cities is a major problem. Whereas FM may be subject to multi-path distortion or rapid variations in signal strength which can make reception quite noisy, DAB+ just drops out completely. One moment you have clear reception and the next you have nothing or maybe words or parts of words sputtering on and off. In this situation, you just switch off in disgust – or go back to FM, if you can. Of course, DAB+ radios normally do not even give you the option of listening to AM!

So DAB+ signal strength in many metropolitan locations is simply not good enough to generate good car radio sales in the future. Commercial Radio Australia may not be happy about that statement but it would difficult to argue against it. There is also a further impediment to acceptance of DAB+ in cars and that is that sound equipment in cars made over the last five years or more is so closely integrated that it is difficult, if not impossible, to upgrade to an aftermarket system, whether it is DAB+ or not. And if car manufacturers are aware of the poor reception of DAB+, why should they make any effort to change?

We have another reason to be critical of DAB+. We put a great deal of development work into the DAB+ tuner that we featured in the issues from October-December 2010 and which has been made available as a kit by Jaycar Electronics. That design potentially delivers the best sound quality that you can get from any DAB+ signal. If we had known that music stations would generally select such poor data bit rates, we would probably not have committed to all that design work which was a major investment on our part. Other organisations who have developed good-quality DAB+ products must feel exactly the same.

Leo Simpson

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MAILBAG

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FutureWave Energy Saver gave a major project saving

I would like to offer a comment on the suggestion of using the MEMS accelerometer for measuring "aircraft bank", raised by Pete Mundy in the Mailbag pages of the September 2011 issue.

Some years ago, I was working on the Flightship ground-effect vehicle project in Cairns and we were trying to find a cost-effective solution to measure what we termed "pitch and roll". MEMS accelerometers were a bit new then but we thought it was worth a try.

At its cruising speed of around 75 knots we found that when making a turn, the craft would roll to about 15°. At this angle, as far as the accelerometer was concerned, it was still perfectly level and if it was not for seeing the horizon the occupants thought so too. So how did we determine we were in fact at 15°? We spent $10,000 on a vertical gyro, which at that time was the only thing that could deal with the problem.

I would also like to comment on the Future Wave Energy Saver. We recently finished installing a large hydroponics system in a building on the Sunshine Coast. It features 22kW of LED lighting, which is another story, but it also used a pair of large pool pumps running in tandem to circulate nutrient. The problem was that one pump was a bit small and two was too much and caused considerable cavitation.

I happened to read the FutureWave review in the June 2011 issue of SILICON CHIP a couple of weeks earlier and the project owner contacted them. They had the prototype dual-pump version on hand and attended the site to make a temporary connection for evaluation. A couple of small adjustments and the pumps worked perfectly and we were even saving about 30% of the running cost.

The normal cure would have been to install a large 3-phase pump and a VSD, so FutureWave saved us far more than the cost of their product.

Gary Smith,
Montrose, Tas.

DAB+ is not the same as DAB in the UK

I am writing regarding the Mailbag letter from Kevin Poulter, Dingley, Vic in the September 2011 issue of SILICON CHIP, featured and highlighted with the heading "Digital radio – the future or just a pipe dream?"

It's hard to know where to start with so much misinformation in one letter. Let me try and correct the glaring errors. Firstly, attempting to link digital radio research in the UK with what is happening with digital radio in Australia is misguided. Digital radio in the UK uses the less spectrum efficient DAB standard, has no slide show capability, is based on a completely different business model, and has only in the last two years implemented an all of industry approach to awareness and marketing.

Mr Poulter writes, "Commercial Radio Australia is claiming that over 500,000 digital radios have been sold since the service was launched two years ago". Commercial Radio Australia (CRA) is not claiming it, digital radio sales are compiled in the GFK Marketscope report where data is collected directly from retailers. The actual number of digital radios is in fact even higher, as the GFK figure doesn't include all categories, all retailers or all online sales.

There is no switch-off date of analogue AM and FM radio services in Australia. Mr Poulter is wrong and is using a 2015 target from the UK, which has no relevance to Australia. Although digital radio is available in Sydney, Melbourne, Brisbane, Adelaide and Perth and covers nearly 60% of the population, the service is not yet available to all Australians. The industry is working with the Federal Government on planning for the roll out of DAB+ digital radio for regional areas.

Again, Mr Poulter writes incorrectly ". . . digital radio has dipped

New antenna gives long-distance reception of DAB+

Just recently, I had my TV antenna upgraded, because of deteriorating reception of Brisbane-based digital TV channels. The result was not just a huge improvement in TV reception but also the SILICON CHIP/Jaycar DAB+/FM radio's reception improved from only three FM stations (with noise) and no digital radio stations at all, to 30 FM stations (limited to 18 on STRONG scan) and 42 DAB+ stations!

Sunshine Antenna Service are as chuffed as I am. There are no digital radio stations on the Sunshine Coast as yet (and none planned) and the Brisbane stations are about 100km distant. But apparently a good VHF/UHF or VHF-only antenna has been found to produce good results in a surprising number of locations around our area.

The SILICON CHIP DAB+ receiver is a beauty! I used an internally mounted 20VA 9V+9V toroidal transformer, placed a 0.5Ω 5W resistor in each secondary (mounted on a piece of terminal strip – extending on the idea published in SILICON CHIP for the 9V plugpack) and mechanically stabilised the recommended larger flag heatsink in the positive rail by attaching it (with a 3mm machine screw and a few 3mm nuts as spacers) to a short length of aluminium angle, which is turn secured to the hole in PCB that was intended for the original mini heatsink.

Peter Roberts,
Maroochydore, Qld.

Denier is a fabric measurement

In a recent editorial (August 2011) the Publisher referred to himself as a (Climate Change) "Denier". I am afraid I have stood by and suffered the use of politically correct rubbish language for far too long without lifting a finger in protest. However, this time I have finally been goaded out of my normal lethargy and I must put fingers to keys to vent my frustration.

"Denier" is a unit of measure for the linear mass density of fibres. It is defined as the mass in grams per 9,000 meters. For those too young to remember, during World War II the girls used to swoon over 15 denier stockings and the Yanks had bucketloads of them, much to the horror of our blokes.

I think what you meant was a "denyer" or possibly a "Deny-er". Better still, how about *Climate Change Agnostic*, a term much more in keeping with the intolerant religious nature of the green cult.

Aside from that, I love the Publisher's editorials. The one in the September issue was great. Old people are suffering and it is wrong. Please continue to sheet the blame where it belongs: with nonsensical green schemes that promote such systems as appallingly expensive and inefficient wind farms that need base stations to function effectively and ridiculously expensive solar schemes.

Keep up the good work but please, no more PC language.

Bob Young,
Riverwood, NSW.

Comment: we agree with the general thrust of your letter but "denier" as in "someone who denies", is a legitimate use of the word.

into our taxpayer's money with little result". The metropolitan commercial radio broadcasters have funded the transmission infrastructure for digital radio. As professional broadcasters they believe this is the radio of the future and that it offers their listeners a chance to experience new content and digital quality sound.

Another sweeping unsubstantiated comment by your reader is, "Portable receivers with almost no exceptions are expensive and can only be heard in mono from an atrocious tiny speaker".

There are more than 100 different DAB+ digital radio models available to purchase in Australia, starting in price from as low as $49. Manufacturers recognise that not everyone wants high-end products that have pause and rewind, pictures, stereo, Wi-Fi and iPod docks and have produced a range of portable, kitchen-top, personal, hifi, clock radio and adaptors that listeners can choose from.

But the most inaccurate information in Mr Poulter's letter is this statement, "Then there are the reception problems. You can listen to AM radio station 3AW right into Gippsland (country Victoria) but not DAB+. 3AW AM consistently wins the ratings".

Your reader is obviously unaware that radio broadcasters are licenced in a specific licence area. 3AW is licensed to broadcast in the Melbourne metropolitan area only. Analogue AM/FM and DAB+ digital radio may in some instances broadcast outside the licence area in what we call "overspill" but the broadcast is not designed or licenced to broadcast outside the licence area.

The reason digital radio is not heard in country Victoria is not a reception issue because there are no digital radio broadcasts in country areas yet. As previously mentioned, the industry is working together with the Federal Government on spectrum planning, to enable all Australians to try digital radio.

It's really disappointing when inaccurate information is printed, whether it's in a letter to the editor or in a story. I would appreciate you publishing my response in full to ensure your SILICON CHIP readers and Mr Poulter have the correct information about digital radio in Australia.

Joan Warner,
Chief Executive Officer,
Commercial Radio Australia.

Kevin Poulter replies: No doubt some of Ms Warner's comments are correct, however rather than a long exchange of views, here are the relevant points that affect most SILICON CHIP readers. Ms Warner says "There is no switch-off date of analogue AM and FM radio services in Australia" but was quoted

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Mailbag: continued

in a recent article in "The Age" as saying that eventually there would be a mandatory switch-over: "Our view is that there would have to be 80 percent or upwards of listening to DAB+ for the industry to agree to switch off analogue. My personal view is that getting to 80 percent will take another five to seven years". Further – "That's 50 million radios that need replacing".

No plans to oust AM? I do have a very recent article that states, quote "The federal government has been a keen supporter of the (digital radio) industry as it seeks to switch analogue users over to digital, in a bid to free up radio spectrum for auction". This would be a red flag to the millions who own multiple AM radio sets in their home and car, especially as it appears to be the intention in the UK.

Choice said earlier in the year that "you'd be better off buying an analogue radio for a fraction of the price" (see the Choice website for much more). In, Melbourne, "The Age" ran a feature: "Listeners give digital radio a poor reception", by Stephen Cauchi on September 4, 2011. See: ***http://www.theage.com.au/technology/technology-news/listeners-give-digital-radio-a-poor-reception-20110903-1jrcg.html***

Nearly every digital radio has a tiny speaker, even those priced up to $700. They just don't deliver the digital quality. I can purchase a superb secondhand Panasonic or other leading brand AM/FM transistor radio or cassette portable radio for $20-$80 and the big speakers deliver excellent sound. Car audio manufacturers expected great things from DAB+ but soon found patchy reception.

I also received comments from other readers, however they are too close to the industry to add their names to this discussion. For example: "I share your concerns regarding the poor audio quality of DAB+; this is a deliberate choice where multi-channel has been chosen above audio fidelity. Unfortunately the younger generation are used to low-fidelity digital audio and know no better"!

One big plus for DAB+ is that it is "green" technology. One 5kW DAB+ transmitter transmits the ABC/SBS ensemble from Mt Dandenong. Compare this to the 50kW output from each of the two AM stations on 621kHz and 774kHz!

The best thing that can be done for consumers is for manufacturers to install bigger speakers. I wish digital radio well but not at the expense of AM.

Kevin Poulter,
Dingley, Vic.

Solar-powered Shed Alarm exit delay extension

I have purchased and built two of the Solar Powered Shed Alarm kits (SILICON CHIP, March 2010) as supplied by Altronics. I have the following suggestion to increase the exit delay from the specified 22 seconds to 50 seconds. Both the kits I purchased (one for me and another for a mate) included a correction to increase the 470kΩ resistor between pin 2 of IC4a and ground to 1MΩ to achieve the desired and specified 22 seconds.

However, it has been my experience that the IRTEC PIR (Altronics SX-5306) is required to have its "settling-in" period at greater than 22 seconds, so that it does not spuriously trigger the alarm at turn-on. As such, I found it necessary to increase the capacitor between V+ to pin 2 of IC4a from 22µF to 47µF, to raise the exit time to about 50 seconds so that the PIR's settling-in time can be accommodated.

Brian Collath,
Moss Vale, NSW.

Discarded microwave ovens are potentially repairable

This email is about microwave ovens that have failed. Firstly, my experience is based on ones discarded for council roadside collections. A large number work once the main fuse is replaced and frequently it is the sole fault. So if your oven dies completely, there is a chance you might be able to fix it by simply replacing the main fuse. These are inevitably inside the oven so the cover needs removing (see later warning).

If the light works and the turntable turns, the main fuse will be OK but check for a second fuse – a number of models have one and it may have blown. That said, I would not use an oven from the roadside for cooking my food . . . their history is unknown. My use for them is quite different.

Another vote for a cassette recorder equivalent

In the Mailbag column of your July 2011 issue you printed a letter from Stuart Hodgson headed "Cassette Recorders Still Wanted". I support what Stuart says in requesting a good-quality sound recorder and player project.

I know that you can buy nifty little digital recorders at various "consumer electronics vendors" but they are not adequate for most tasks. Most have very poor speakers and their frequency response seems to be very limited. Also, there is no option to remove and physically save a particular recording.

Such a project should include a high-quality built-in microphone, plus a socket to connect to an external microphone. It should also have a good-quality amplifier and internal speaker, plus the option of using an external speaker or being able to feed the signal into an external sound system.

The recording medium should be removable/replaceable to allow external storage of particular soundtracks. For my use, monophonic would be adequate but maybe it could be made as a stereo system.

For portability, particularly for recording, it should carry its own energy source and to save batteries (or recharge the internal ones) be able to connect to 230VAC as well.

Anthony Mott,
Blackburn,Vic.

Some interesting information I came across on the web might save someone some money. I checked the specific case quoted and it was correct.

When the magnetron fails, the oven appears to work but no heat is generated. When they fail, the price quoted

Mailbag: continued

Criticism of Jim Rowe's design

Yet again, Jim Rowe (Improved Stability For The GPS-Based Frequency Reference, September 2011) has missed the point that the TC (terminal count) or ripple-carry output of a 74HC160 isn't guaranteed to be glitch-free.

Unlike a Johnson counter (such as the 74HC4017) several of the flipflops may change state at the same time. Any mismatch in propagation delays of the flipflops or of the inputs to the combinatorial logic used to generate the TC output will inevitably lead to glitches in the TC output. Consequently, the TC output should never be used to clock subsequent logic.

Whilst it is possible that a particular 74HC160 may not appear to generate such glitches, this is no guarantee that all 74HC160s will never do so for some combination of operating voltage, temperature and manufacturing process variations.

The real problem in synchronously cascading 74HC160s with a 10MHz clock is the internal propagation delay to the TC output is too long to allow sufficient set-up time for the last 74HC160 in the chain, if one uses the naive cascading method illustrated in the 74HC160 data sheet. The alternative method in the data sheet illustrates the look-ahead method of cascading 74HC160s that allows much faster clocking of a 74HC160 chain.

However, if one wishes to synchronously cascade a chain of 74HC160s with a JK flipflop, then the TC output of the first and last 74HC160 in the chain should be ANDed together and used to drive the J and K inputs of the flipflop.

Unfortunately the worst case propagation delays when HCMOS logic is used do not allow reliable 10MHz operation for all chips as there is insufficient set-up time available for the JK inputs of the flipflop. Reliable ripple clocking of the subsequent flipflop can be achieved by using the Q3 output of the last 74HC160 to drive the clock input of the subsequent JK input with its J and K inputs tied high. This eliminates the inverter as the initial phase of the last 74HC160 is unimportant and the glitch-free Q3 output only changes from 0 to 1 once every 10µs.

Another potential issue is that outputs of the two halves of the JK flipflop will either be in phase or 180° out of phase as there is no guarantee that the two flipflops will have the same initial state.

Yet another potential issue is that insufficient isolation between the two oscillators used can lead to injection locking which destroys the desired averaging effect when the two oscillators are not locked.

Even a pair of OCXOs (oven-controlled crystal oscillators) like the HP10811A exhibit this phenomenon when their output frequencies approach too closely. In this case, adding a buffer stage with sufficient reverse isolation eliminates this problem.

Bruce Griffiths,
Hamilton, NZ.

Comment: Jim Rowe has now begun a long and arduous trek to a monastery in Nepal to do good works and make amends for his peccadiloes. We wish him well and hope that he can be back soon after his rehabilitation, to continue his contributions to SILICON CHIP.

Seriously, in the light of the above revelations, we have to wonder about the utility of the TC output on these devices if it cannot be guaranteed to be glitch-free.

to fix it is often close to that of a new oven and seldom under $180.

WES in Ashfield, Sydney sell most styles of magnetron for $40-$68. That potentially saves you $100 if the magnetron has actually died. But most interesting, a number of magnetrons have a 10-year warranty. So, if you have your oven receipt, the cost of a replacement magnetron could be zero. If over 10 years old, your oven has worked for you for 6-9c a day, so be grateful.

I do not claim this warranty applies to every brand of magnetron in every oven but it certainly does for some (eg, GE). The labour may or may not be free. Regardless, claim the replacement magnetron and fit it yourself – or with help.

Be aware of the precautions in-

volved – high (lethal) voltages linger inside even after unplugging and turning off. Ensure that the capacitor(s) are discharged and ask a competent friend for help if you need it.

Brett Cupitt,
via email.

Enthusiastic report on portable headphone amplifier

I've just completed my the Portable Headphone Amplifier (SILICON CHIP, April 2011). It's a great unit! It looks good and It sounds LOTS better than from straight out of the MP3 player or iPod! It gives surprisingly deep bass, even from my old 32-ohm Sony MDR-40 headphones! It has lots of volume – more than enough! As you said, "Turn the (digital) volume control right up on your iPod and use the volume control on the headphone amp". The music sounds much "cleaner" overall.

There is one problem though! You did mention in the article how RF interference could "break through" the plastic case. Well it does! If my mobile phone rings nearby, a very loud and typical mobile phone "buzzing & clicking" sound bursts through the music.

We were warned I guess but would lining the case-halves with a conductive, earthed shield of some kind help? Does anyone make thin self-adhesive aluminium sheet? What about that nickel-based aerosol for shielding? A ferrite bead or two somewhere maybe? You have already included RF filtering right at the audio input of the amp, so the RFI is probably not coming in via the input signal lead. What about via the headphone cable? Maybe there's room in the case for even just a sheet of earthed tinplate shield on the copper side of the board.

Apart from the mobile phone interference, this unit is very quiet – when it's not belting out the rock'n'roll that is! There's no background hiss or hum. Nothing. Even when you switch it on or off with no signal there's silence – a good reason to have a red LED in the power pushbutton (so you know it's actually on).

I would thoroughly recommend this amplifier to anyone who is tired of the tinny distorted sound from their portable music players.

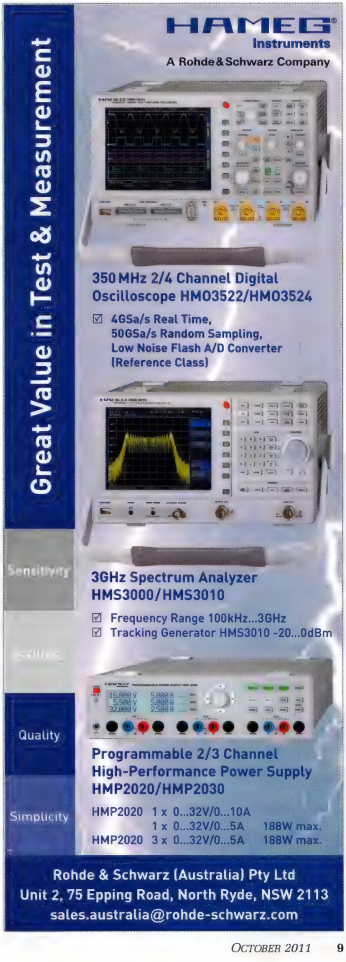
Nev Goddard,
Blue Haven, NSW.

Comment: there is no easy way to remove the loud clicks and noises due to mobile phones. Threading the signal lead a couple times through a small ferrite toroid may help though.

Kelvin-Varley potentiometer featured – almost

In his July 2011 Circuit Notebook article, Jim Rowe seems to have reinvented the Kelvin-Varley potentiometer originally devised by William Thompson (Lord Kelvin) and a colleague towards the end of the nineteenth century. However, the classic circuit uses fewer components.

To convert the circuit of page 91 to the classic form: (1) discard the resistors connected to S1b contact B; (2) connect S1b contacts A, B & C to S1a contacts C,



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Mailbag: continued

D & E respectively and increase the value of the 100Ω resistor connected to VR2 to 300Ω. Finally, adjust VR2 for a total resistance (including VR1) of 200Ω, reducing the effective resistance between the S1 wipers to 100Ω, which is the necessary condition for contiguous steps.

Incidentally, VR1 could be replaced by a second identical Kelvin-Varley potentiometer providing 2% steps.

The Kelvin-Varley potentiometer was a common device in measurement laboratories up to the early 1970s. The usual implementation used three or four cascaded stages with 10-position switches (11 resistors per stage). Excited by either an AC or a DC reference voltage, it could be used as an adjustable voltage source or, by adjusting it to match an unknown voltage, as a measurement device.

In either case, with a suitable choice of excitation, the voltage could be read directly from the switch positions. Several early ADC designs used Kelvin-Varley potentiometers with the manual switches replaced by banks of relays or uniselectors (essentially solenoid-stepped rotary switches originally designed for telephone exchanges).

Tony Ellis,
Porirua, NZ.

USB charging information

In response to Bruce Pierson's suggestion in SILICON CHIP June 2011, the USB charging specification actually requires that the data pins be shorted to make a USB charging port – see Battery Charging v1.2 Specification, section 1.4.7, page 3 (available from **www.usb.org/developers/devclass_docs).**

A port constructed with the data pins shorted can be used to charge most GPS units, phones and other devices designed around the official USB charging specification but devices such as iPhones use their own propriety specification and will not be compatible.

Andrew James,
Bathurst, NSW.

Query on aircraft flap actuator story

I'm enjoying the new "Serviceman" articles but one entitled "Aircraft flap actuator" (March 2011) caught my attention and is still bugging me a little. A repair job involving a bearing, shaft and circlip unfortunately failed, with possible catastrophic results, when the (original?) circlip apparently dislodged after replacement in reassembly.

In my strictly limited (amateur) automotive and allied experience, I had gained an impression that it was standard practice to replace parts like circlips (surely consumables?) during the reassembly process. This notion could be applied to similar electronic repairs – use a new part because the original may have been over-stressed.

I have no background to criticise a professionally-trained serviceman but I would have thought that in aircraft repairs at least, caution would have demanded a new circlip. I've clearly been watching too many "Aircrash Investigations" but I would welcome clarification on the servicing protocol.

Brian Graham,
Mount Waverley, Vic.

Dave Thompson replies: the circlip, bearing and most of the other moving components in that flap actuator job were indeed brand spanking new, replacing any items removed during the component overhaul. You are correct in saying that these should indeed be used only once and replaced if removed, due to fatigue and stress both in use and in removing them.

The fact that it was new and failed was one of the worrying aspects of the whole situation and the remaining parts in our stores at the time were tested and found to be sound. So this one seemed to be that one-in-a-million that go wrong. I just happened to have signed it out. SC

Flash drives should be formatted

With reference to letter on this topic in the August 2011 issue of SILICON CHIP, USB flash drives are not as simple to use as one would think. There is the matter of media files. These cause the operating system on the source computer to record the drive letter that the drive had at the time it was written to, along with the flash drive serial number. This is done so that when it is reinserted, the operating system can assign it the same drive letter it had before.

This can cause the drive to fail to read in some cases.

On the matter of the drive appearing to fill up, it is necessary to format the drive to clean it. Deleting doesn't do the job fully. Format also removes any remnants of media files as these can stay even when the files appear to be deleted. If used regularly for transfer of data you may need to use a drive wiper to clean out the remnants from the spare sectors (as mentioned in the letter in August 2011). I observed the above by accident when having trouble and found it to work for me.

Note also that the bigger the flash drive, the more prone it is to this problem. I find it starts mildly with 4GB drives and worsens as the size increases.

Robert O'Connor,
Mildura, Vic.

Design With Low Power, High Precision Op Amps

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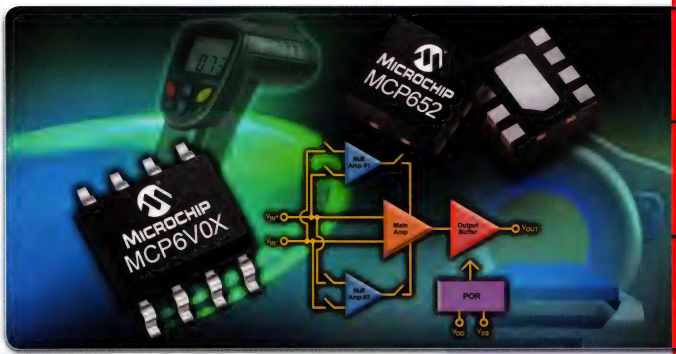

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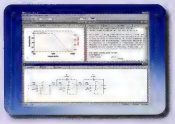

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We've all seen them: boring electronic quiz games which sound a buzzer or bell and light a light to tell you which contestant has pressed their button first. Ho-hum. Yawn. But there's nothing boring about our QUIZZICAL! It will certainly judge the winner – even if there's only microseconds between contestants hitting their buttons!
But wait, there's more: you don't just hear a buzzer or bell, you hear a sound effect or tune that's different for each player. And you can change that sound effect or tune whenever you like.

If you've ever watched the quirky British show "QI" (here's today's trivia or tomorrow's quiz question – it stands for Quite Interesting), or perhaps the witty Aussie "Talking About Your Generation" you'll know what we are talking about.

When each player or contestant presses their buttons (well, more often than not, belts their buttons!) as well as judging who's first, each responds with individual sound bites. Those sounds are often surprising, sometimes outrageous and always humorous. And they're never the same from one episode to the next.

Build the SILICON CHIP **Quizzical!** and similar, virtually limitless sound possibilities are yours. That's because the **Quizzical!** uses a Secure Digital (SD) memory card to store the sound files and so any MP3 file can be included for play.

There is no limit to the types of sounds that can be produced – anything from animal noises, explosions, opera and classical music through to one liners from cartoons, comedy skits or movies. Like "Go ahead, make my day!"

How?

If you know how to save an MP3 sound file on your computer and can then copy that to an SD card, you can use the **Quizzical!**. It doesn't record files itself; it simply plays back files that have been stored onto the SD memory.

What?

For suitable sound files, you don't have to search far. In just a few minutes searching on the net, we found literally millions of MP3 files.

These ranged from Warner Brothers Bugs Bunny cartoon classic one-liners, Monty Python sound bites, Star Wars and other science fiction sounds, bell sounds and music MP3 files and ring tones.

You can edit sound files to any length before placing these onto the memory card. If they are other formats (eg .WAV or .M4A) there's plenty of free software around to convert them to MP3.

Or you can record your own sounds using an MP3 player with recording facility or using a computer and microphone and freely available software. Even bits of CD tracks can be converted to MP3 format suitable for the **Quizzical!**. (Bear in mind the warning in the "Legalities" panel).

Who?

Quizzical! caters for up to four contestants plus the adjudicator (dare we call him the QuizzMaster?). Once a player has pressed his or her button to answer a question, his/her unique sound

by JOHN CLARKE

Quizzical! Features

- Up to four contestants plus QuizzMaster
- Unique sounds played for each contestant
- Unique sound during answer period and at end of answer period
- Up to five separate sets of theme sounds can be stored on SD card
- Internal speaker
- External speaker output connector
- Volume control
- Optional externally-accessible SD card slot
- Adjustable contestant play sound period
- Adjustable answer period
- Unlimited types of sounds possible

starts to play and his/her button lights up. And all other answer buttons are locked out at this time.

The contestant sound play period can be set by a trimpot adjustment and is available from between 1.3s and 18s. But if those periods are not suitable, there is also the option to have the play period set by the sound file length.

The QuizzMaster can cancel any sound playing by pressing the QuizzMaster button.

This pushbutton also has a LED indicator. Additionally, the QuizzMaster can start a timer to limit the time period allowed between the quiz question and for an answer. During this answer-timing period, a new sound (the QuizzMaster sound) can be played.

When?

This answer-timing period can be set internally to between 1.3s and 35s or by the file length itself. At the end of the timing period, a different sound can be played to indicate timeout. The QuizzMaster LED lights during the answer-timing period.

If another contestant presses a contestant button during the answer-timing period, then his or her contestant sound is played.

But that sound arrangement is quite flexible – you have the choice to play a "silent" file during the answer-timing period which, of course, means that no sound is heard.

At the end of the answer-timing period a sound indicates the time has expired. Or you could have a sound played during the answer-timing period with a silent file for the end of the timing period.

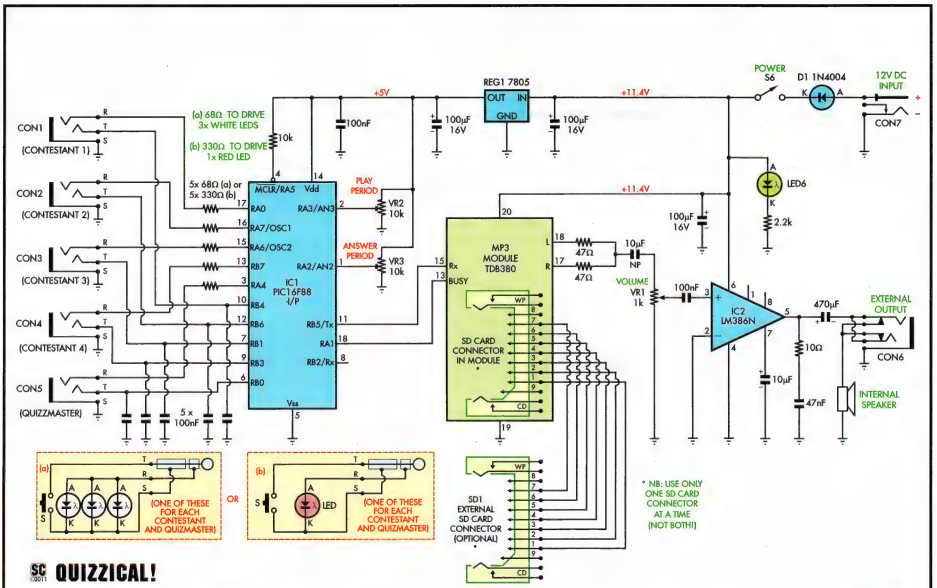
If the answer-timing feature is not required at all, the QuizzMaster does not press the QuizzMaster button to initiate the answer-period.

If the QuizzMaster button is pressed unintentionally, the button can be pressed again to immediately cancel the answer period sound.

The contestants' buttons still operate in the same way, where as soon as one button is pressed the other contestant buttons are inactive until the contestant sound file finishes playing.

Themes and variations!

The **Quizzical** can include up to five separate sound themes that are written onto separate folders on the



SC QUIZZICAL!

Fig.1: the circuit consists of the player push-buttons/LEDs, a PIC microcontroller, a proprietary MP3 module and an audio amplifier. Construction shouldn't take much more than an hour or so. The five resistors between the sockets and PIC can be 68Ω (for the modified shed lights) or 330Ω if you use a single red LED in the box.

SD memory card.

By way of example, the first folder might contain the four separate files for the contestants, an answer period file and end of answer period file, all based on a cartoon theme. The second folder might have a science fiction theme and the third folder might have a classical music theme and so on.

Other uses

The MP3 module which the **Quizzical!** is based on is quite a useful little device. So much so that we imagine the **Quizzical!** will not be restricted to games use. The push buttons can be used for other purposes to initiate sounds.

Perhaps you'd like a doorbell where each doorbell push-button switch gives a different sound? Easy with the **Quizzical!**

Alternatively, the **Quizzical!** could be used simply as a sound bite generator to generate a variety of sounds on demand. Want to introduce sound effects to a school play? Store 'em on the **Quizzical!** and play them (perhaps over a PA amplifier?) at the appropriate time by pressing the appropriate button.

But its main use is, of course, for quizzes and games. You could take control over all the contestant and QuizzMaster buttons and play suitable interjection noises associated with answers: for example cheers for correct answers, boos for incorrect answers.

You get the picture (or actually the sound), we're sure.

Physically speaking . . .

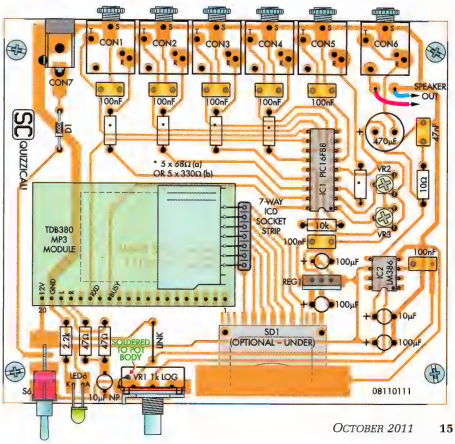
Quizzical! is housed in a small plastic case, which contains all the electronics except for the contestant and QuizzMaster pushbutton switches.

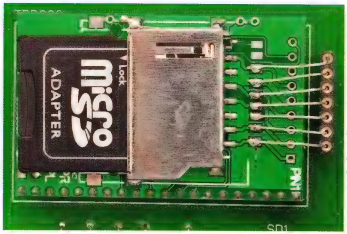
These are connected via suitable lengths of twin shielded cable and 3.5mm stereo jack plugs which connect into the back of **Quizzical!**.

We'll have more to say on these pushbuttons a little later because we have something pretty special lined up there . . .

There is a small loudspeaker within the case to produce the sounds but for best sound, a socket is included to connect a larger loudspeaker or for connection to a sound system. When a jack plug is inserted into this socket, the internal loudspeaker is

Inside the Quizzical! case – this does have the external SD card slot added but it's under the PCB. Fig.2, below, shows how and where.





An enlarged view of the TDB830 MP3 module and its method of connection to the underlying PCB. The seven wire connecting links at the right side can be made with resistor lead offcuts (assuming, of course, they're long enough!).

automatically disconnected. A volume control is included on the front panel along with a power switch and power indicator.

The SD card

The card normally slots into place in a connector directly on the MP3 module. However, this is inside the case and may be at least a little inconvenient to use – especially if you want to swap sounds.

So we have made provision for an external SD card, accessed via a slot on the front panel.

This requires the addition of a few extra parts including an SD card connector. Having the externally accessible SD card connector does not prevent use of the SD card connector that is on the MP3 module itself but note: only one SD memory card can be used at the one time.

At the rear of the **Quizzical!** are six 3.5mm stereo jack sockets – four for the leads to the contestant pushbuttons, one for the QuizzMaster pushbutton and one for the loudspeaker outlet. Power is via a DC power socket using a 9 or 12VDC plugpack or a 12V battery.

It is not recommended to use a small 9V battery to power the **Quizzical!**, as the battery will be discharged rather quickly.

Maximum current drain is about 200mA or so while playing sound at maximum volume, so using a 12V gel cell is perfectly practical and proper! It drops to as low as 45mA on standby.

Circuit

The **Quizzical!** is based around a Tenda Electronics TDB380 MP3 Module and a PIC16F88 microcontroller (IC1). The microcontroller is used to monitor the contestant switches (S1-S4) and QuizzMaster (S5) switch and to drive the LEDs associated with each switch. The microcontroller also, operates the MP3 module via a serial connection and monitors the trimpots provided for playback and answer period adjustment.

Switches S1 to S5 are monitored via the RB4, RB6, RB1, RB3 and RB0 inputs of IC1 (respectively). The switches and LEDs share a common ground; each of the switches connects to the 3.5mm plug tip while the LEDs connect via the ring.

Internal pull-up resistors within IC1 keep the switch inputs at 5V unless a switch is pressed, pulling the input to 0V. Each switch input is bypassed with a 100nF capacitor to prevent noise and interference from falsely triggering an input.

Switch contact bounce is not a problem as the microprocessor responds to the very first switch closure and ignores any other switch input – from that switch or any other.

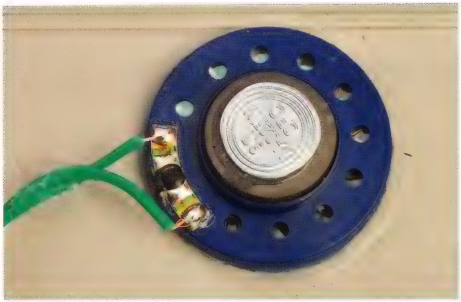
Indicator LEDs, LED1 to LED5 associated with each switch are driven from the RA0, RA7, RA6, RB7 and RA4 outputs respectively via suitable series resistors (we'll have more to say on these shortly).

Trimpots VR2 and VR3 connect across the 5V supply and therefore provide a voltage to the AN3 and AN2 inputs ranging between 0 and 5V. The microcontroller converts the voltages into digital values which in turn set the timeout for the answer and play periods.

VR2 settings between 0V and about 4.5V provide a play period between 1.3s to 18s respectively. Similarly, VR3 settings between 0V and 4.5V provide an answer period between 1.3s and 35s respectively. The advantage of these timers is that the MP3 file lengths for each sound do not have to be individually edited to set the playing period. Instead the timers handle all play lengths.

However, if you want longer periods or if you want different length play periods for each player, then the required trimpot (or both) can be set fully clockwise. This results in 5V at the AN3 and/or AN2 input. Then the

The rear panel of the Quizzical! has is a DC power socket (9-12V DC from plugpack or gell cell battery), along with six 3.5mm jack sockets – four for the contestant push-buttons, one for the QuizzMaster push-button and one for the mono external speaker output (which could also be used to connect it to an external amplifier/speaker for some really dynamic sound)!



The tiny 8Ω speaker is glued to the case lid *after* you first drill a series of "sound holes". Note also the glob of silicone sealant (at left) providing strain relief.

MP3 file length sets the timeout period. This period can range from zero seconds to any file length.

The TDB380 MP3 Module is controlled by the microcontroller using a serial connection between the transmit (Tx) output of IC1 (pin 11) to the Rx input of the module.

Baud rate is 4800bps with 8-bit data and one stop bit. A precise baud rate is not critical and we tested for successful operation with baud rates ranging from 5000bps to 4464bps. With that range of workable baud rate, the microcontroller can run from its internal oscillator that has a nominal 2% tolerance at normal room temperature, rather than having to use a crystal for a more precise baud rate.

With serial control any number of files can be selected, from 1 to 199 in any one folder. There are 15 folders available. For our **Quizzical!** we only use up to six files in each folder and there are five folders that can be accessed. The default folder is folder 1. This is also called the root directory.

Sending a play command to the Rx serial input of the module plays a file. Each file is individually selected using a separate serial code. When the module is playing a file, a stop command can be sent to the TDB380 to cease play. Stop has high priority and operates immediately.

This is in contrast to sending a file 'play' command when a file is already playing. The module will wait until the file has completed before playing the next file. To play a new file before the current file has finished playing, a stop command has to be sent first to stop the current file playing and then the new file command is sent.

The busy flag output from the TDB380 module is monitored by the microcontroller's AN1 input for indication of when a file has finished play. During play, the busy pin is low (close to 0V) while the end of file is indicated with a high (2.2V) signal which indicates the module is not busy. The AN1 input checks if the voltage is above or below the mid point of these two voltage levels. So if voltage is below 1.1V, then the module is busy and if the voltage is above 1.1V then the module is ready (not busy).

Monitoring of the busy signal is useful for determining when a file has finished. That information is used by the microcontroller to ensure a contestant cannot play his or her unique sound if another contestant has already pressed their button, starting a file playing. The busy signal also informs the microcontroller when the answer period has expired, when this is set to the file length of the answer period file.

For files that are longer than about two seconds, pressing the QuizzMaster switch will cease play immediately. Also another file can be played immediately after the first file has completed by pressing a contestant pushbutton. These are the expected responses from the MP3 player to stop and play commands.

The MP3 module has a few quirks that occur when playing MP3 files shorter than about two seconds in length. If a second contestant pushbutton were pressed within a couple of seconds after playing this short file then the second file would not always play. We overcame this quirk by checking the busy signal to find out if the second file has started. Should the second file not begin to play a second or two after the first file has finished, then the 'play the second file' command is re-sent.

Ceasing play of a file that is two seconds or less in length using the QuizzMaster pushbutton is not always possible with this module. But it is not really a problem as it is only a short file anyway. You will just have to wait it out.

Audio out

Audio signal from the MP3 module is at the left and right channel outputs at pins 18 and 17 respectively. We used two 47Ω resistors to mix the left and right channels into a mono signal. The mono signal is AC-coupled via a 10µF non-polarised capacitor to a 1kΩ volume control. These resistances are made low in value to minimise induced noise into the audio from the MP3 player as the Player reads the SD memory card.

Low-level switching noises in the audio signal would otherwise be evident, especially when using the external SD card connector. Another way we minimise this noise is to use a metal front panel, which connects to

Legal issues

Strictly speaking, with the exception of sounds you create and record yourself, any sound files you play using the **Quizzical!** are subject to copyright – especially if you use it in a public place or for example, broadcast a quiz using them.

That applies to sounds you download from the web, grabs from CDs, even things like ringtones (which we imagine will be pretty popular on **Quizzical!**).

More information concerning the playing of copyrighted sounds in public, including sampled sounds, can be found in the information sheet G089.pdf from the Australian Copyright Council (**copyright.org.au**) on Music: DJs.

Parts List – Quizzical

Main unit

1 PCB coded 08110111, 115 x 102mm
1 ABS Instrument Case 140 x 110 x 35mm
1 SD memory card 32MB to 2GB (A lower range capacity is all that is required)
1 TENDA TDB380 MP3 module
1 134 x 31 x 1mm sheet of Aluminium for front panel
6 3.5mm PCB mount stereo jack sockets (CON1-CON6)
1 PCB mount DC socket with 2.5mm contact pin (CON7)
1 SPDT PCB mount toggle switch (S6) (Altronics S1421 or equivalent)
1 40mm Mylar 8Ω speaker
1 DIP18 IC socket
1 knob to suit VR1
3 PC stakes
4 M3 x 6mm screws
1 60mm length of 0.7mm tinned copper wire
1 150mm length of hookup wire

Semiconductors

1 PIC16F88-I/P microcontroller (IC1) programmed with 0811011A.hex
1 LM386N 1W amplifier (IC2)
1 7805T 5V three terminal regulator (REG1)
1 1N4004 1A diode (D1)
1 3mm green LED (LED6)

Capacitors

1 470µF 16V PC electrolytic
3 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
1 10µF NP electrolytic
7 100nF MKT polyester
1 47nF MKT polyester

Resistors (0.25W, 1%)

1 10kΩ 1 2.2kΩ 5 330Ω/68Ω *
2 47Ω 1 10Ω (* see text)
2 10kΩ horizontal mount miniature trimpots (VR2, VR3)
1 16mm 1kΩ log potentiometer with two nuts (VR1)

Externally accessible SD Card option

1 SD memory card holder (Jaycar PS0024 or equivalent)
1 7-way wire wrap socket strip
1 120mm length of 0.5mm tinned copper wire

Quizzical! Specifications

Power supply:	9 to 12VDC at up to 250mA. Standby current 60mA.
Loudspeaker power:	Typically 0.4W into 4Ω and 8Ω
Contestant sound play:	1.3s to 18s (or sound file length)
Answer sound play:	1.3s to 35s (or sound file length)
File type:	Plays MP3 files (only) with standard bit rates ranging from 32kb/s to 320kb/s.
Memory card:	32MB to 2GB SD card using FAT16 or FAT32
Folders:	Up to 5 folders accessible with six MP3 files per folder

the volume pot body and circuit earth and forms a shield.

Using the 1kΩ volume potentiometer, bass response is rolled off due to 1µF audio coupling capacitors in the left and right channel outputs on the MP3 module itself. If you require more lower frequency bass, then the potentiometer should be replaced with a 10kΩ log pot instead (at the risk of more noise).

Following the volume control, signal is coupled via a 100nF capacitor into an LM386N amplifier, IC2. This drives a loudspeaker via a 470µF coupling capacitor. Supply bypassing for IC2 is with a 100µF capacitor across the 11.4V supply and the 10µF capacitor at pin 7. The 10Ω resistor and 47nF capacitor connected in series at the pin 5 output prevent high frequency oscillation when an inductive load such as a loudspeaker is connected.

Power

Power for the **Quizzical!** is from a 9V or 12VDC plugpack or from a 12V battery. Diode D1 provides reverse polarity protection for the circuit and switch S6 applies power with indication by LED6. The 11.4V (or 8.4V with a 9V supply) is applied to the REG1 input, the TDB380 module supply pin and the pin 6 supply pin for IC2.

REG1 supplies 5V for IC1. The supply is bypassed with a 100µF capacitor and 100nF capacitor. IC1 includes a power on reset using the 10kΩ resistor at the MCLR input (pin 4) to the 5V supply.

Note that while the TDB380 MP3 Module is powered from 11.4V, an integral regulator reduces the voltage to around 3.3V for the on-board ICs and SD memory card.

Other considerations for the mismatched supply voltage are when monitoring outputs from the MP3 module. A high level output from the module can only reach a maximum of 3.3V and this may not be recognised as a high by the microcontroller running from 5V. In our circuit we use an analog input for monitoring the busy signal and so we can set the high threshold to a more suitable voltage as discussed earlier.

When power is applied to the **Quizzical!** circuit, it takes a few seconds before the MP3 module becomes functional. This period is indicated by LED1 through to LED5 all lighting up. When the LEDs are extinguished, the MP3 module is sent a serial command that sets the volume at its maximum level. This volume is an internal digital volume control, not the external VR1 control. The **Quizzical!** is then ready to operate.

Construction

The **Quizzical!** is constructed using a PCB coded 08110111 and measuring 115 x 102mm. The MP3 module mounts directly onto this PCB. The assembled PCB is housed in an ABS instrument case measuring 140 x 110 x 35mm.

Begin construction by checking the PCB for shorts between tracks and pads, missing holes and for correct hole sizes. Make repairs as necessary.

If you intend to use the externally accessible SD memory card socket, this is installed on the underside of the PCB. Solder the 13 pins at the rear of the connector and the two pins at the front of the connector to the PCB pads. Take care that the 13 pins do not have any solder shorting bridges between them. (These can be cleared with solder wick and a soldering iron to draw off any excess solder between pins).

Install the low profile components first. These are the wire link, the resistors and diode D1. When installing the resistors, use a multimeter to check the resistance value. Diode D1 must be oriented correctly.

IC1 is installed using an 18-pin

DIL IC socket but IC2 can be directly installed on the PCB. Make sure the IC socket and IC2 are oriented correctly. Leave IC1 out of its socket at the present. CON1 to CON6, 3.5mm jack sockets, can be installed now as well as CON7, the DC socket. The three PC stakes can be installed with two located behind CON6 and one adjacent to VR1.

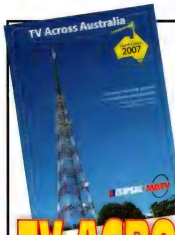
The MP3 module has a 20-way right angle header along one side for external connections. The right angle in each pin needs to be bent straight so that the module can be installed horizontally onto the PCB. Carefully bend each pin using pliers so that each pin is fully straightened. Insert the module pins into the PCB holes with the module sitting about 10mm above the PCB surface. Solder the pins to the PCB.

The capacitors, regulator and switch (S6) can be mounted now. Make sure the polarised electrolytic capacitors are mounted with the shown polarity. The 10µF NP capacitor can go in either way. REG1 is mounted with the metal tab toward the front of the PCB. It doesn't need a heatsink. Fit the trimpots (VR2 and VR3) now.

If the potentiometer (VR1) supplied has a normal-length shaft it will require cutting to 10mm overall length. The pot body also needs to be connected to the PC stake located adjacent to it. This is done using a short length of tinned copper wire (eg, a resistor lead cut-off).

To allow solder to adhere to the outside of the pot body, a small area (ie, immediately around where it is to be soldered) normally needs to be scraped off just before soldering the wire in place.

LED6, the "power" LED, is mounted with the anode (longer lead) closest to VR1 and with the leads bent at right angles 5mm back from the LED body. The LED is positioned at the same height above the PCB as the S1 switch ferrule.



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External SD card socket

The externally-accessible SD card holder (if used), needs to be connected to the MP3 module via a 7-way IDC socket strip and wire links (see photo).

Install the 7-way IDC socket strip alongside the MP3 module. This socket strip is placed so that it sits 10mm above the PCB. Seven lengths of 0.5mm tinned copper wire, each 17mm long, then connect the MP3 module to the 7-way socket strip.

Make a right-angle bend at 5mm along each wire length. Insert the short ends of each wire into each socket strip hole and position each wire to sit over the solder pads that connect to the seven used pins of the SD card holder on the MP3 module. Carefully solder each wire to the MP3 PCB.

Note that there is more than one version of this MP3 module currently available. We originally designed the Quiz Game using version 1 (V1.0) of the module. This version had the SD card positioned to the far right and the wires from the socket strip needed to solder directly to the pins on the module's SD card holder.

The MP3 module shown in the photographs is version 8.3 (V8.3) and has the SD card holder located centrally on the MP3 module. This has PCB pads available that allow connection to the SD card connector pins without resorting to soldering directly to the connector pins.

There may be other versions being sold – which one you have with will depend on the supplier of the MP3

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
EITHER ❑	5	330Ω	orange orange brown brown	orange orange black black brown
OR * ❑	5	68Ω	blue grey black brown	blue grey black gold brown
❑	2	47Ω	yellow violet black brown	yellow violet black gold brown
(*see text) ❑	1	10Ω	brown black black brown	brown black black gold brown

Placing and arranging Quizzical! sound files onto the SD memory card

The final part of building the **Quizzical!** is to acquire and place MP3 files onto the SD memory card. This needs to be done using a computer. Most computers these days have SD card readers installed (or perhaps MMC card readers; for our purposes they are identical).

Modern printers and monitors often have an SD slot that enables reading the SD memory when connected to the computer. Failing this, external USB SD card readers (which invariably are also writers) are available for just a couple of dollars.

The SD card should already be formatted with either the FAT16 or FAT32 file system. If it is not formatted, this can be done using the format facility on your computer.

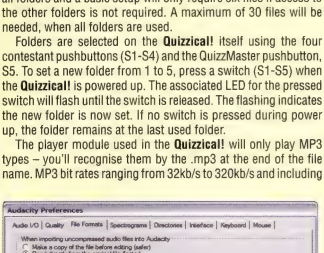
Files

The **Quizzical!** requires six sound files per folder. Four files are for the four contestants sounds, the fifth one is for the answer-period sound and the final file is for the end of answer-period sound. The answer-period and end of answer-period files can either be files that produce a sound when played or they can be silent files where no sound is heard. It is important that six files are placed in each folder.

One of five folders can be selected when using the **Quizzical!**. That means that you can have five separate themes for the **Quizzical!** sounds with one theme per folder. It is not necessary to use all folders and a basic setup will only require six files if access to the other folders is not required. A maximum of 30 files will be needed, when all folders are used.

Folders are selected on the **Quizzical!** itself using the four contestant pushbuttons (S1-S4) and the QuizzMaster pushbutton, S5. To set a new folder from 1 to 5, press a switch (S1-S5) when the **Quizzical!** is powered up. The associated LED for the pressed switch will flash until the switch is released. The flashing indicates the new folder is now set. If no switch is pressed during power up, the folder remains at the last used folder.

The player module used in the **Quizzical!** will only play MP3 types – you'll recognise them by the .mp3 at the end of the file name. MP3 bit rates ranging from 32kb/s to 320kb/s and including variable bit rate (VBR) are suitable. Other file types of files such as .wav and .m4p will have to be converted to MP3 format before they can be used with the **Quizzical!**.



Audacity can be downloaded from the net (http://audacity.soundforge.net/download/) and is perfect for editing and converting Quizzical! file formats if a suitable MP3 codec (eg lame_enc.dll) is first loaded (eg from http://lame.buanzo.com.ar/).

Where do you get them?

Audio files for your **Quizzical!** are easily obtainable from sources such as CDs and downloads from the Internet. Files from the CD can be ripped and imported as MP3 files. Files from the Internet ideally should be either ones that are purchased or free of charge and royalty free. For more detail see the section entitled Legal Issues.

Files can be edited for length and for content within the file, so when looking for suitable files do not be put off because the file is too large. If it contains a section you wish to use then this can be selected and made into a shorter file. It is important that the file plays immediately, ie, there is no "dead air" at the start of the MP3 file. Any "dead air" can be edited out with a variety of sound file editors.

Files that are already short may be directly suited for contestant and end of answer-period files. The time periods these files are played are set by the play period adjustment using VR2 or by file length. Up to 16s play period is available via the VR2 setting or this can be set longer as set by file length.

A file for the answer period needs to be long enough to give contestants "thinking" time as well as answering time. The answer period can be set (using VR3) for up to 35s or by file length. So if you want a longer than 35s period, then the file needs to be longer at the required timeout length. If you prefer not to have sound during the answer-period, then a silent file can be used.

Sound files are commonly available on the Internet and a good list of sites is available at **www.teachers.ash.org.au/suel/freestuff/sounds.html** Music files are available from download sites such as iTUNES at **www.apple.com/au/itunes/** Special interest sites for audio files include ones for the Looney Tunes cartoons at **www.nonstick.com/sounds/**; Monty Python at **www.intriguing.com/mp/sounds.php**; Science fiction at **http://itunes.apple.com/au/artist/science-fiction-sounds/id169052199** and general sounds at **www.soundjay.com**.

If the files can be downloaded as MP3 types then this will save having to convert the files. But if a file is only available in wave format, it is not difficult to convert the file.

.m4p files

Files with a .m4p suffix are not as easily converted to MP3 format as they are AAC protected files (MPEG-4 protected Advanced Audio Coding audio files). Most of the files that are downloaded using iTUNES are .m4p files.

You could purchase a commercial m4p to mp3 converter (such as available from **www.m4p-mp3.com**) or alternatively, a relatively inexpensive way when only a few files are to be converted is to first make a CD of the .m4p files you wish to use. This can be done in iTunes where the required files are placed on a playlist. The CD is burnt as an audio CD rather than as a data disc.

You can use mono or stereo MP3 files as the stereo output is mixed into a mono signal

File handling

Once you have the necessary MP3 files for your **Quizzical!** you may wish to edit them. Editing can improve the sound file by having the relevant section of the file start as soon as the file is played and you can set the file length.

File editing can be done in Audacity. The start and end position of a file can be selected by wiping over the required file section with the mouse cursor and exporting the selection as an MP3 file. Editing allows a file to start exactly at the sound point you require. It can also select when you wish the file to end.

Additionally, it may be worthwhile normalising or compressing each file. Normalising sets the effective volume of the file to a standard level, while compression reduces higher volume levels reducing the overall dynamic range. With these processes, each file will have a similar sound level when played.

To do this, select the file and Effect/Normalise or Compressor. Other Effects that you might wish to use is to change the pitch, speed or tempo, reverse the file or add in echo. These features are also available under the Effects tab.

Creating a silent file

When you wish to play silence rather than a sound for the **Quizzical!**, you will need to have an MP3 file that has no sound.

To create a silent MP3 file, first open a new file (file, new) then select Generate/Silence. Type in the desired length (in seconds) then click OK.

Placing files onto the SD card

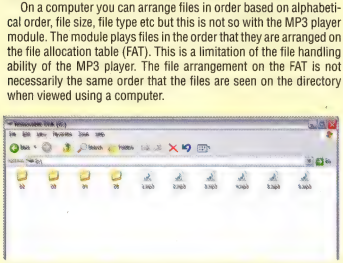
The SD card needs to have each set of six sound files placed in separate folders. The first folder is the root directory (folder1). This folder is not named but it is assumed to be the 01 directory. It should contain the first set of four contestant files; the answer-period sound file and the end of answer period sound file totalling six files.

For the **Quizzical!** to work correctly, these six files must be present. Files can be silent if required but a missing file cannot be used in place of a silent file.

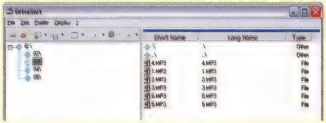
Another set of six files can be placed in folder2. You can create up to five folders. Folders should be named 02, 03, 04 and 05. The first folder is the root directory where the first six files are placed. In the accompanying screen shot, (see SD Folders screenshot below) we show .mp3 files named from 1.mp3 to 6.mp3 in the root directory plus the other four folders.

One thing to note is the order that the **Quizzical!** plays the files. The first four files (1 to 4) should be the contestant sound files. The next file (5.mp3) should be the answer-period file and the end of answer-period file is 6.mp3. This is straightforward – but there is a trap.

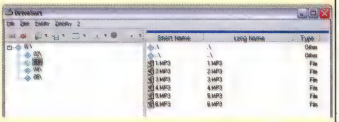
On a computer you can arrange files in order based on alphabetical order, file size, file type etc but this is not so with the MP3 player module. The module plays files in the order that they are arranged on the file allocation table (FAT). This is a limitation of the file handling ability of the MP3 player. The file arrangement on the FAT is not necessarily the same order that the files are seen on the directory when viewed using a computer.



Screen grab of our "SD Folders" with files ready for use by Quizzical! Note the order and naming is important – it's explained in the text.



Two screengrabs showing the difference between an unsorted file list (above) and the same files having been sorted into correct order (below).



The simplest way to get the file order correct is to start with a blank folder and then copy the files onto it one at a time, in the order required. This operation must also be applied to folder creation, ie, they must be created in numerical order. However, there may be some situations in which this approach can fail.

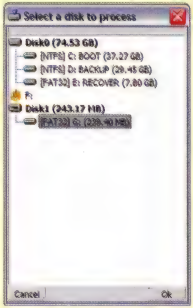
Another method is more certain to ensure correct file order when the **Quizzical!** operates. Files are renamed in each folder to 1.mp3 to 6.mp3 corresponding to players 1-4 and 5.mp3 for the answer-period file and 6.mp3 as the end of answer-period file. A file sorting utility is then used to rearrange the FAT to correspond to the file numbering.

For more detail on this file order problem see **www.anerly.net/software/file/DriveSort.php**. You can also download the Drive Sort utility from this site and the 'download file' button is at the bottom the page at that site. Once the file has downloaded, open the zip file; extract the files and place onto a suitable directory (folder) on your computer hard drive. Run the DriveSort.exe file.

Once the utility is running, select Disk open (see left) and open the SD memory card. Select the folders and the contained files will be shown, in the order arranged by the FAT. Note that the files are not necessarily in numerical order.

To order the files, Select: Order/Ascending and then Folder/Sort. Folders will be sorted in ascending order. Then select Folder/Save to save this file order.

Repeat for all folders including those at the root directory. This also sorts the folders in order. Select Disk/close to exit the program.



The "Drive Sort" utility downloaded from www.anerty.com (see text).

module and how much stock they have of a particular version.

Enclosure

Work can now begin on the enclosure. It's a two-part box and you will find that the two halves only go together one way. Front and rear panels are separate and, as mentioned earlier, an aluminium panel is substituted for the plastic front panel supplied.

Holes are required for the power switch, LED and potentiometer on the front panel and for the 3.5mm jack sockets and DC socket on the rear panel. Hole positions and hole sizes are shown in the panel artwork (downloadable from **siliconchip.com.au**) with hole positions and sizes shown.

When the externally accessible SD memory card holder is used, a slot is also required on the front panel. The outline for this cut-out is shown on the front panel artwork.

The small loudspeaker is positioned inside the top lid toward the rear of the box. Holes are drilled through the lid over the loudspeaker cone area (before the speaker is glued in!) We used neutral cure silicone sealant, although many other types of glues are suitable including hot melt, contact adhesive and other plastics glues. Simply run a thin bead of glue around the speaker edge and allow it to dry.

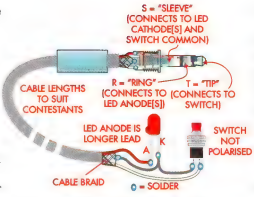


Fig.3: here's how to wire each of the contestant and Quizzmaster push-buttons to the 3.5mm plugs.

The front and rear panel labels, which are glued to the panels, can be printed onto paper, photo paper, film or similar and glued to the panel. Cut the holes out with a sharp craft knife or leather punch.

The finished panels are attached to the front and rear of the PCB with the nuts for the 3.5mm sockets securing the rear panel and the pot nuts securing the front panel. We used two nuts on the pot, one behind the panel and the other on the front of the panel. The rear nut is to space the panel from the pot so the panel is positioned correctly in the case.

The PCB and panels are secured in the bottom half of the case with four M3 screws that screw into the four corner posts of the box. There are extra mounting posts in the case that foul the PCB, preventing it from sitting flat. These can be removed by twisting off using pliers. Finally, the speaker is wired to the PCB loudspeaker PC stakes using hookup wire. A dollop of glue can be used to hold the speaker wires to the case lid, removing any stress on the soldered joins.

Testing

With all four player and single QuizzMaster pushbutton units plugged in, apply power and switch on with S1. Check that LEDs 1-5 light for a few seconds after powering up.

The power LED (LED6) should remain lit. Measure the voltage between pins 5 and 14 of the IC1 socket. This voltage should be close to 5V. If the voltage is outside the range of 4.85 to 5.15V, then check for a possible short circuit across the 5V supply. Also check that there is voltage at the input to REG1.

When the 5V supply is correct, switch off power and insert IC1. Further testing can be done after the SD card is written with MP3 files.

TENDA Electronics TDB380 MP3 player module

Measuring 51 x 33 x 8mm, the MP3 player can be used as a music player, a sampler sound box, doorbell, announcer and many other similar applications requiring sound.

The module operates from between 6V and 24V at up to 100mA and plays MP3 files that are stored on an SD memory card. Up to 199 MP3 files can be accessed on each of 15 folders for a total of 2985 files. Sound output is in stereo at up to 200mVp-p at the output. This output can drive headphones directly, although it will be a low level and the 1µF on board coupling capacitors will roll off the bass.

There are four ways that the module can be used. Two methods simply have switches attached to the inputs to allow playing of the various files on the memory.

For the MP3 player mode, switches allow the module to operate as a normal player. In this mode it has volume, play, pause, stop, previous, next, fast forward and reverse, plus change memory folder (directory) functions.

The second switch-operated mode allows independent selection of up to eight files. Volume and random play are also available. This mode is ideal for doorbell, robot sounds, announcements etc.

The remaining two modes require a computer or microcontroller to drive the MP3 module via parallel or serial data connection.

Each mode is selected by setting two solder link connections as either open or closed. For the serial mode, this will operate with any jumper link setting.

The data sheet for the TDB380 module is available from **www.thaieasyelec.net/archives/Manual/TDB380%20datasheet%20V2%5B1%5D.0%20.pdf**

The MP3 module is manufactured by Tenda Electronics (**www.tendaelectronics.com**) and is based around a Shanghai Mountain View Silicon Technology AU6850 MP3 decoder.

Some of its features include:

- SD/MMC card reader controller
- Supports MP3 (MPEG 1/2/2.5 layer-III decoder) at 32-320kbps and Variable Bit Rate
- Supports 9 sampling frequencies: 8kHz, 11.025kHz, 12kHz, 16kHz, 22.05kHz, 24kHz, 32kHz, 44.1kHz and 48kHz
- Supports FAT16 and FAT32 file systems
- Embedded 16-bit sigma-delta audio DAC
- Embedded headphone amplifier

The module is available from the USA at **www.mdfly.com/** for approximately $16.00 inc postage. You could also try Rictech in Melbourne (graeme.rixon@yahoo.com).

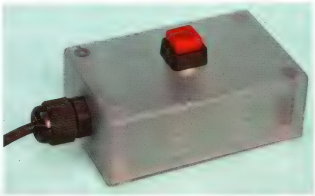
Failing that, Tenda Electronics do sell direct to the public as "samples" but their website doesn't have a shopfront: you have to do it all by email and Paypal.

Also watch the one-off freight charges – they can be very steep (eg, four times the unit price!).

THE "EASY" PUSH-BUTTONS

When we first developed this project, we used ordinary push-button switches mounted with a high-brightness LED in a small translucent jiffy box.

Now there is nothing wrong with this approach but having watched QI and TAYG many times, we thought they were a little underwhelming. We wanted a **PUSH-BUTTON**, not a PUSH-BUTTON.



Admittedly, this approach is probably a bit easier so we'll show it here, along with its parts list, for those who want to go this route.

It's not at all critical where the pushbutton goes (but logic suggests the centre) and as it and the LED share a common (-) connection, the LED could simply have its cathode soldered to this point.

Player and QuizzMaster switch and indicator

(Uses 330Ω resistor on PCB)

- 5 UB5 (83 x 54 x 31mm) clear boxes (eg, Jaycar HB-6015, H0205)
- 5 SP momentary push button switches (S1-S5) (Altronics S1080, Jaycar SP0716)
- 5 5mm high intensity LEDs
- 5 5mm LED panel clips
- 5 cable glands for 3mm cable
- 5 stereo 3.5mm jack plugs
- 2-core screened cable (length to suit installation)

THE "PRO" PUSH-BUTTONS

We went searching for the large push buttons as used on those shows and yes, they were available but no, they were FAR too expensive.

That's when we started thinking "outside the square" (OK, I was taking a walk through my "other home" – Bunnings) and I came across the small (100mm) battery-operated LED lights pictured here.

They're sold as either push lights or night lights, depending where you shop. Brand is "Magic Living"; (Bunnings barcode 9337897 001 942).

The price was certainly right – about $7 for two! – but the only problem was they had push-on, push-off switches. We needed momentary.

I also spotted a larger version of the same thing, with somewhat similar electronics, which would be perfect for the "QuizzMaster" controller.

After disassembling one of these to see if I could get the switch apart easily and convert it to momentary, I quickly gave up that idea. Too small, too flimsy (although if you want to give it a go, be my guest. Nothing ventured and all that!)

So I thought "what about fitting a different switch?" The biggest problem here was that the moulding suited the fitted switch and nothing else that I could find would go close.

The other difficulty was that the travel in the switch had to be pretty well spot-on.

After various measurements and tests, I bought a couple of tiny momentary switches from Jaycar (SP-0603) and glued them in place using JB Weld.

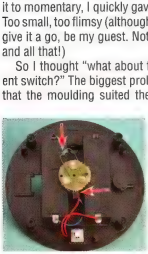
While that was drying I turned my attention to the LEDs. There are three of them, all white high-brightness types, mounted in parallel on a small PCB, along with a tiny inverter to step up the 3V from the two "AA" cells to give enough to light the LEDs.

As the PIC outputs 5V, I knew I didn't need the inverter so I whipped it out and tested the whole thing out on a 5V supply. Voila!

The 330Ω resistor specified in the original circuit is much too high to get the required brightness so I replaced it with a 68Ω, which limits the current to safe levels for the PIC output.

And that is how we ended up with our "pro" contestant push buttons. A length of two-wire shielded cable, exactly as per original, was soldered to the PCB and run out through the now-vacant battery area.

The 150mm light has a 6V supply (4xAA cells) so therefore has no inverter. But you will need to remove its internal resistor, change the switch to momentary and run it as above from the PIC and 68Ω resistor. SC



Remove the four screws (carefully!) to reveal the 3-LED PCB and switch. Prise out the switch and glue a mini momentary type switch (eg Jaycar SP-0603) in its place. Make sure the height of the new switch actuator is the same as the original switch. Also prise out the LED PCB and unsolder the two components (arrowed) – they are not required.

Wire a suitable length of shielded two-wire cable to the LED PCB and the switch. They share a common earth. Reassemble the light (don't lose the tiny springs or screws. . .) and you're ready for action. Repeat for the other four push-button lights.

MUSIC-CONTROLLED DISPLAYS:

DIGITAL XMAS LED LIGHTING CONTROLLER

It's that time of year again when all those Christmas lighting devotees start planning and building their displays for the festive season. They might have dozens – if not hundreds – of different light arrays and they will be thinking about buying even more. Is this you? Have you thought about controlling lots of your lights in time to music? Well now you can!

Our spectacular Digital Lighting Controller, which we presented last year (October-December 2010), could drive an impressive array of incandescent globes.

But while it proved to be very popular, no sooner had we gone to press than many readers started reminding us that most Christmas Lights are now made of 12V LED strings. D'oh!

So now we've made up a new Slave Controller. It suits the original master unit but can now drive up to eight strings of LEDs, each string with completely individual control.

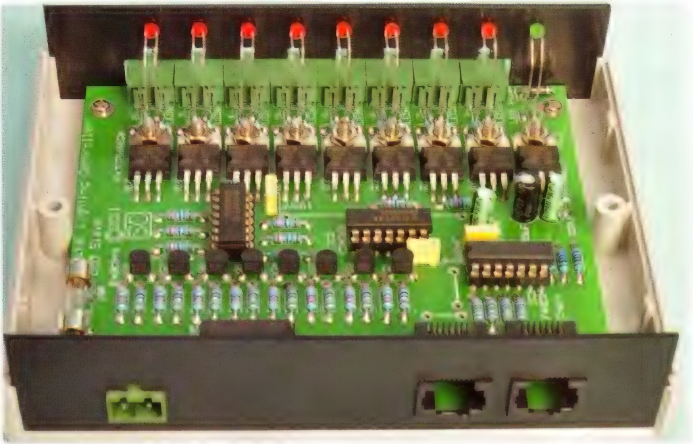
And you can have up to four slaves so that you can drive up to 32 channels.

Woo-hoo!

Furthermore, if you run the whole shebang from 24V DC instead of 12V DC, you can have twice the number of LED strings, by running LED strings in series.

Wow! Think of the possibilities. You can control thousands of LEDs!

Another – these days fairly significant – advantage of going LED is that controlling lots of incandescent lamps means that you are going to get a big



This rear-view inside shot shows the complete Digital Lighting Controller LED Slave – it uses the same master unit as published this time last year. By comparison with last year's slave, the biggest difference is the size of the box – it's much smaller – and the row of semiconductors down the middle – the Triacs are now replaced by Mosfets.

electricity bill for the festive season. LEDs are a much cheaper proposition.

Digital LED control

Before we get down to the details of the Slave LED Controller, we need to review the main features of the Digital Lighting Controller presented last year.

The whole system is controlled by the master unit which is housed in a small plastic box. This is controlled via a hand-held remote and takes an SD card (or MMC or SDHC card).

This contains WAV music file(s) and sequencer file(s) (which you set up) and it sends serial commands via a Cat5/6 cable to the slave lighting controllers. These can drive incandescent lights or as presented in this article, lots of LED strings.

You can have up to four slave units and so you could have, for example, three slave units each driving LEDs and one slave driving incandescent lamps. Or any other combination involving up to four slaves.

For the rest of this article we will concentrate on the slave LED controller. If you want all the information involving the incandescent controller and the master unit itself, you will need to refer back to the original articles (ie, October, November & December 2010).

If you don't have these issues, you can purchase them from Silicon Chip or you can access them on our website (for a small fee).

Going to the Master and slave LED controllers, Fig.1 shows the overall set-up with one master and up to four slaves.

The slave units are daisy-chained via Cat5 ethernet cable, as each has RJ45 input and loop out jack sockets.

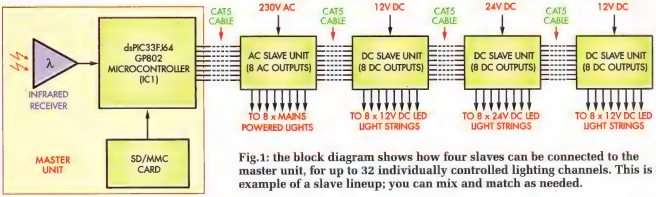
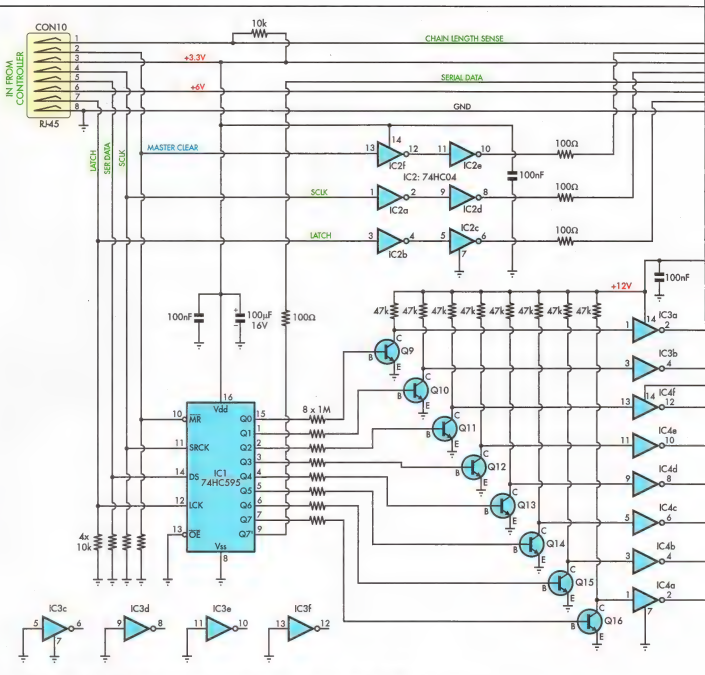


Fig.1: the block diagram shows how four slaves can be connected to the master unit, for up to 32 individually controlled lighting channels. This is one example of a slave lineup; you can mix and match as needed.



SC DIGITAL LIGHTING CONTROLLER LED SLAVE MODULE

Fig.2: the complete circuit for the LED slave unit. IC1 receives and decodes serial data from the master unit while IC2 buffers the serial output to the next slave unit. Q9-Q16 and IC3-4 level shift IC1's outputs to drive Mosfets Q1-8. These then switch current through the LED strings connected to CON1-8 and the internal indicator LEDs1-8. The data from the master unit adjusts the LED string brightness using pulse width modulation (PWM). Power for the LED strings is supplied from CON9 via a 10A fuse while REG1 provides a nominally 12V rail for driving the Mosfets.

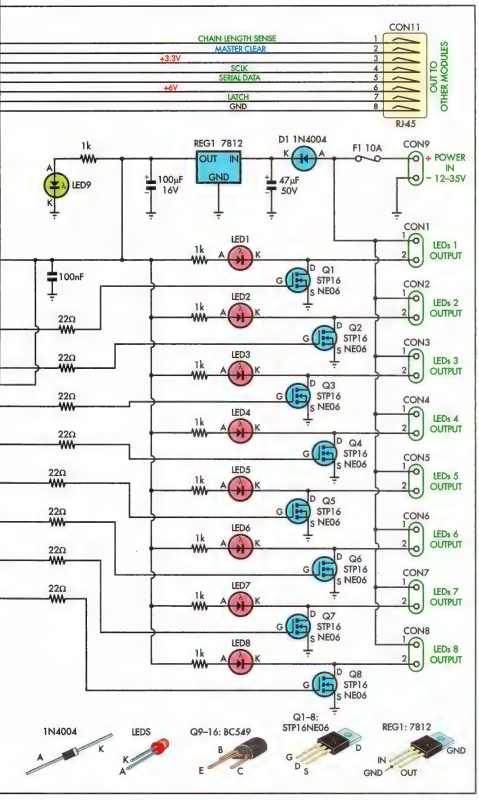
In addition, to enable a large lighting display to be set up, the connecting cables can be up to 30 metres long.

This means you can have the master unit safely inside your home and the slave units can be a long way distant, provided you can feed 12 or 24V DC to them to power the LED strings.

While the incandescent light slave controller is housed in a relatively large plastic instrument case (as it has to accommodate eight Triac circuits and eight IEC power sockets), the LED slave controller comes in a compact plastic case about the same size as the master unit.

Pulse width modulation

The brightness of the LED strings is controlled using pulse width modulation (PWM), ie, DC power to the LEDs is switched on and off rapidly. The switching frequency is twice mains frequency, so 100Hz for Australia, New Zealand and the UK (or 60Hz/120Hz in



many other parts of the planet).

The ratio of the on-time to the switching period (10ms) is known as the duty cycle and the higher the duty cycle, the brighter the LEDs appear.

The original incandescent light slave unit switches the 230VAC to the lights using a slightly different method known as phase control.

For phase control, the switch-off always occurs at the mains zero crossing as the Triac switching devices remain in their conducting state whileever the current through them is above a threshold. There are two zero crossings per mains cycle, hence the 100Hz frequency (or 120Hz for a 60Hz mains supply).

To determine when the Triacs should be switched on, the mains voltage waveform is monitored and they are triggered at a particular phase angle, hence the term "phase control". The power delivered to the load is proportional to the RMS voltage across it, which is related to the area under the partial sinewave.

Since PWM and phase control are quite similar, the master unit software only needs minor changes to suit both. The changes are (1) holding the outputs on for the entire on-period rather than just an initial pulse to trigger the Triac and (2) calculating the on-period based on a square wave rather than a sinewave.

Anticipating a DC slave, these options were built into the original master unit software.

The "triac turnoff <slave> = delayed" (where <slave> is a number from 1 to 4) option forces the outputs to stay on for the entire on-time.

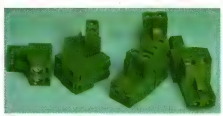
For AC slaves, this option increases power consumption but the DC slave has no optocouplers so in this case it won't.

The previously undocumented "slave type <slave> = DC" option tells the master unit to compute on-times for a square wave (PWM) rather than a sine wave (phase control). Without this option, the DC slave will still operate but with less linear brightness control.

Connectors

We decided to use pluggable terminal blocks for the DC power into the slave unit and the LED strings. These are readily available, have a sufficient current rating (12A) and are easy to make connections to. The right-angle PCB mounting types allow the connectors to protrude through the front and rear panels of the case, so connections can be made without removing the lid.

Since the eight output connectors are identical, it's also easy to swap



These pluggable right-angle screw connectors make setting up (and modifying) your masterpiece real easy!

LEDs around (or even between slaves) as necessary.

For the communication ports, we are using the same "Type II" 8P8C (RJ-45) connectors as in the original (AC) slave unit.

Circuit description

Refer to the circuit diagram, Fig.2. The serial interface is virtually identical to that of the AC slave published previously. This consists of IC1 and IC2, 8P8C (RJ-45) connectors CON10 & CON11 and some associated passive components.

A Cat5 type cable runs from the master unit to CON10. The eight conductors carry low voltage DC power (3.3V and 6V), serial data from the master and a "chain length sense" line which allows the master to detect the number of slaves connected.

The 3.3V rail powers the slave's digital logic ICs while the 6V provides power for optocoupler LEDs, used only by AC (mains) slaves. The 3.3V rail has a 100µF bulk bypass capacitor and 100nF high frequency bypass capacitors for each connected IC.

The serial lines are: bit clock (SCLK, pin 4), data (SERIAL DATA, pin 5), master clear (pin 2, active low) and latch (pin 7). Each slave receives eight bits of data on this bus and when the latch line goes low, the output state is updated to reflect the latest data received. The master clear line is used to turn all outputs off at power-up.

Because the cable between units may be up to 30m long, the four serial lines are terminated to ground with 10kΩ resistors. This forces some current to flow when the lines are driven high, reducing switching glitches due to the transmission line nature of the cabling.

Each slave connects pin 1 to 3.3V via a 10kΩ resistor. These are therefore in parallel. A resistor in the master unit from this pin to ground forms a voltage divider with them and by sensing the voltage at the junction, it can tell how many slaves are connected. When fewer slaves are connected, less data needs to be transmitted to update the

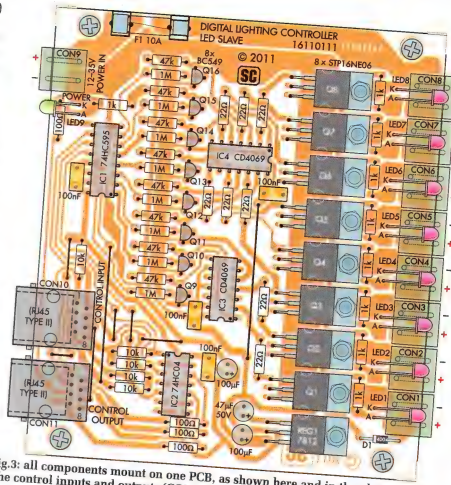
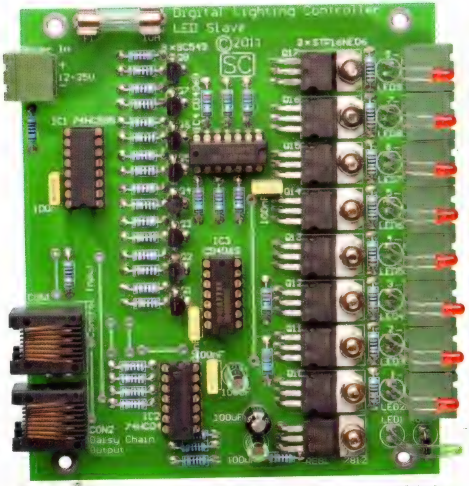


Fig.3: all components mount on one PCB, as shown here and in the photo at right. The control inputs and outputs (CON10 and CON11), the DC power input (CON9) and the power indicator (LED9) go on the rear panel while the eight output connectors (CON1-8) and indicator LEDs (LED1-8) are fitted to the front panel.

The finished project mounted in its case, complete with push-on screw terminals. The green LED at left shows that power is connected but in the final version, it is on the rear panel, not the front.



There is a difference between this prototype photo and the diagram at left: the green power LED (LED9) has been moved to the rear panel to give more space to the front panel connectors. Otherwise it's identical.

output state.

CON11 is the daisy-chain output and may be connected to another slave unit, allowing up to four to be controlled by a single master, as already noted. This avoids the need for multiple outputs on the master unit and simplifies the wiring.

The three power lines and the chain length sense line pass through directly from CON10 to CON11 but the four serial lines are buffered. The bit clock, clear and latch signals each pass through two 74HC04 inverter gates (IC2a-f).

By inverting each signal twice the polarity is preserved. Since the lines are buffered by each slave, the master output only needs to drive one length of wire. 100Ω series resistors form RC filters with the cable capacitance, filtering out switching glitches.

The serial data from the master unit (or from the daisy chain Cat5 cable) passes through IC1, the 74HC595 serial-to-parallel latch IC, delaying it by eight clocks. As a result, each slave receives a different portion of the data, which is stored in IC1's eight internal latches. When the latch (LCK) line goes low, this data is transferred to its output latches, appearing at QA-QH (pins 15 and 1-7).

Level shifting

These outputs then control eight Mosfets which switch power to the LEDs. When a latch output is high, that LED string is turned on and when the output is low, it is off.

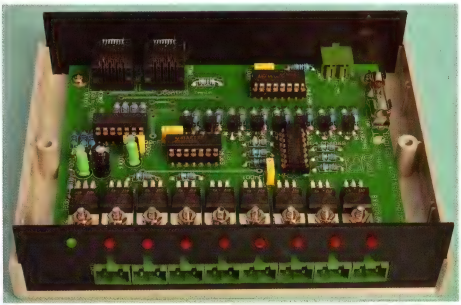
Since IC1 runs from the 3.3V rail, its outputs swing between 0V and 3.3V. While this is sufficient to turn on some Mosfets, the types specified for this project require at least 8V to turn on fully. Even "logic level" Mosfets typically require at least 4.5V for full conduction.

So we must "level shift" the 0-3.3V output signal of the 74HC595 to 0-12V (or so) to drive the Mosfets. This is achieved with eight NPN transistors (Q9-Q16), two hex CMOS inverter ICs (IC3 and IC4) and some resistors.

Each of IC1's outputs drives the base of an NPN transistor via a 1MΩ resistor. When an output is high, the corresponding transistor is driven with about (3.3V – 0.6V) ÷ 1MΩ = 2.7μA. The minimum h_{FE} for a BC549 transistor at low currents is 110, so we can expect its collector to sink at least 2.7μA x 110 = ~300μA.

Each collectors has a 47kΩ pull-up resistor to the 12V rail, so to be driven into saturation, the transistors must sink around 12V / 47kΩ = 255μA. Therefore the collector voltage swing will be close to 12V.

This level shifter configuration is inverting, ie, when IC1's output goes



This time shown from the front (and without the connectors in situ) the PCB mounted inside the case. The eight panel LEDs mimic the controlled LEDs.

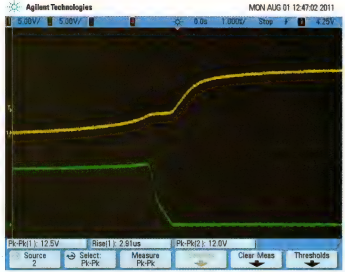


Fig.4: the Mosfet gate waveform (yellow) and drain voltage (green) as the Mosfet is being switched on. The Mosfet gate voltage rises at a rate determined by the current capability of the driver and its input capacitance, until it reaches the threshold voltage. At this point the Mosfet starts to turn on and its drain voltage drops but the gate voltage rise is temporarily halted due to the Miller effect. Once the Mosfet is fully on, the gate voltage continues to rise to the full drive voltage, reducing the channel on-state resistance to its minimum.

high, the corresponding transistor collector goes low and vice versa. So we invert the signal again with CD4069 CMOS inverter ICs.

Output drivers

Each 4069 inverter drives a Mosfet gate via a 22Ω resistor. This resistor forms an RC filter with the Mosfet's input capacitance, eliminating gate voltage spikes that could be caused by stray inductance in PCB tracks and component leads.

For efficiency, it's best to switch Mosfets gates rapidly, since during each switching transition the Mosfet is in a state of partial conduction and this increases the average dissipation. To achieve rapid switching, high current drive is needed to quickly charge and discharge the Mosfet's gate capacitance.

The output current of the 4069 inverter is typically about 8mA, much lower than a purpose-designed Mosfet driver. But this is mitigated by the low switching frequency (100Hz) and the relative low gate capacitance of the Mosfets we have specified of around 760pF (compared to 1960pF for an IRF540N or 5480pF for an IRF1405).

Fig.3 shows a scope grab of the Mosfet gate and drain voltages during switching. The yellow trace is the gate voltage and the green trace the drain. The rise in gate voltage briefly halts as it reaches the on-threshold due to gate-drain ("Miller") capacitance. Before and after the actual transition, the gate voltage slew rate is limited by gate-source capacitance; the sources are connected to ground.

By adding up the positive and negative transition times (the latter is slightly longer than the former) we can see that the Mosfets spend around 2µs switching every 10ms, ie, 0.02% of the time. This increases the Mosfet dissipation by a negligible amount compared to that due to their on-state resistance while carrying the load current.

Note that Fig.3 shows the transition time for a light load; it is longer for higher currents since the Mosfet must be turned on harder. But even if this doubles the switching time, it's still very short.

The specified Mosfets have an on-resistance is around 0.1Ω and this is what ultimately limits LED string RMS current. At the rated 2.5A, dissipation for each Mosfet is around $0.1\Omega \times 2.5A^2 = 625mW$; much more than this and the TO-220 packages will get hot, since they do not have heatsinks.

Since the full supply voltage is applied across the LED string when the associated Mosfet is on, each LED string needs to incorporate a current-limiting resistor or active current limiter. This limiter is usually incorporated in the string.

As well as driving the outputs, the Mosfets also pull current through red indicator LEDs (LEDs1-8). These are powered from the 12V rail via 1kΩ current limiting resistors. They are useful for checking and monitoring the operation of the device. Depending on the DC supply voltage, they are driven with 8-12mA each.

Power supply

DC power for the LED strings and driver circuitry is connected to CON9, another pluggable terminal block. A 10A inline fuse protects against a board fault, shorted output or current overload. The DC input can be 12V or 24V. Just remember that for a 24V supply, your 12V LED strings must be connected as series pairs.

The power supply used need not be rated for the full 10A if your LED strings, when combined, will not draw that much. An easy and cheap way to get a high current (10A+) 12V DC supply is to use a spare computer power supply; see our article in the January 2011 issue of SILICON CHIP on how to modify one for standalone use.

The 12V rail is derived from the DC supply by REG1, a standard 3-terminal 12V linear regulator with associated input bypass and output filter capacitors. It is protected from reversed supply polarity by diode D1. This does not protect outputs CON1-CON8 but since the connected LED strings act as diodes, they won't conduct unless the supply polarity is correct anyway.

If the DC supply is 12V, REG1 will be in dropout and so the nominally 12V rail will actually be a lower, unregulated voltage (around 10V). The Mosfets and their drivers operate normally under this condition. Regulation is only necessary to protect ICs3-4 and Q1-8 from damage in case the supply voltage is above 15V or 20V respectively.

A green power LED across the 12V supply (again with a 1kΩ current limiting resistor) indicates when supply voltage is present. On our prototype, it is on the front panel but it has been moved to the rear panel of the final version, to allow the output connectors to be spaced further apart.

While this circuit has two power supplies (3.3V from the master unit and 12-35V for the LEDs), it does not matter in which order they are applied. If the master unit is powered up first, IC1 can switch transistors Q9-16 on but they will have no collector voltage and so the inputs of IC3 and IC4 will remain at 0V.

Alternatively, if power is applied to CON9 before the master unit is switched on, LED9 will light but the inputs to IC3 and IC4 will remain high, as there will be no current from IC1 to turn on Q9-16. There will therefore be no gate

drive voltage for Mosfets Q1-8 and so they will remain off. Normal operation begins only when both the master and slave units are powered up.

Construction

All parts mount on a single 103 x 118mm PCB, coded 16110111. Referring to the overlay diagram (Fig.2), begin by installing the eight wire links using 0.7mm diameter tinned copper wire. If you have a double-sided board, like our prototype, these may be omitted.

Next, install the resistors, checking the value of each with a DMM set to Ohms mode (since the colour codes can be hard to read). A standard lead bending jig can be used except for the eight 1kΩ resistors adjacent to Mosfets Q1-Q8 which have a closer pad spacing. Follow with diode D1, orientating it as shown on the overlay diagram.

Fit the four ICs next, paying careful attention to their orientation (IC2 faces the opposite direction to IC1 and IC3). If using the optional IC sockets, solder them in instead.

The eight Mosfets and the regulator go in next (don't get them mixed up!) First bend the TO-220 package's leads down 90° about 6mm from the tab and then mount it with a 10mm M3 machine screw passing up from the underside of the board, with a shakeproof washers under the head and under the nut. This is vital since the output current passes through the mounting screws.

Make sure they are fully tightened before soldering the leads or else you could damage the board.

That done, install the eight BC549 transistors, cranking the leads out with small pliers to suit the pad spacing. The four MKT capacitors can go in next, followed by the three electrolytic capacitors, with their longer leads through the holes nearest the "+" signs on the overlay diagram. Don't get the two different types mixed up.

Then solder the fuse clips, taking care that they are pushed right down on the PCB and that the locating tabs go towards the outside.

Follow with the nine right-angle terminal block sockets, ensuring that they are all flush against the board and perpendicular to its edges. If you installed the IC sockets earlier, plug in the ICs now, careful with their orientation.

Fit the 10A fuse, then solder the two 8P8C (RJ-45) connectors in place, making sure they are flush with the PCB.

The red LEDs go in next. Install them with the maximum lead length possible, with just enough through the bottom of board to solder to. In each case, the longer lead goes through the hole towards the bottom of the PCB.

For the green LED, first bend its leads by 90° 5mm from the lens. Check its correct orientation before doing so (its longer lead also goes towards the bottom). Solder it so that the horizontal portion of the leads is 4mm above the surface of the PCB.

Parts list – LED Slave for Digital Lighting Controller

1 PCB coded 16110111, 103 x 118 mm
1 ABS plastic enclosure, 140 x 110 x 35mm (Jaycar HB5970, Altronics H0472)
1 front panel label
1 rear panel label
2 low profile PCB-mount RJ-45 sockets (Altronics P1448 or similar)
9 PCB-mount 2-way horizontal pluggable terminal blocks, 5.08mm pitch (Jaycar HM3102, Altronics P2592)
9 2-way pluggable terminal block sockets, 5.08mm pitch (Jaycar HM3122, Altronics P2512)
2 M205 fuse clips
1 M205 10A fuse
9 M3 x 10mm machine screws and nuts
18 M3 shakeproof washers
4 No.4 x 9mm self-tapping screws
1 200mm length 0.7mm diameter tinned copper wire
1 16-pin DIL socket (optional)
3 14-pin DIL sockets (optional)

Semiconductors
1 74HC595 octal serial-to-parallel latch IC (IC1)
1 74HC04 hex inverter IC (IC2)
2 CD4069 hex inverter ICs (IC3, IC4)
1 7812 12V 1A linear regulator (REG1)
8 STP16NE06 or MTP3055E Mosfets (Q1-8)
8 BC549 NPN transistors (Q9-16)
1 1N4004 1A diode (D1)
8 3mm red LEDs (LEDs1-8)
1 3mm green LED (LED9)

Capacitors
2 100µF 16V electrolytic
1 47µF 50V electrolytic
4 100nF MKT

Resistors
8 1MΩ 8 47kΩ 5 10kΩ
9 1kΩ 4 100Ω 8 22Ω

Assembly

The next step is to make the cut-outs and holes for the front and rear panel, using Fig.5 as a guide. The easiest way is to photocopy or download and print the diagrams, then cut them out (including the holes, using a sharp hobby knife or a leather punch) and glue or tape them to the panels.

Use a 3mm drill to make the nine LED holes. For the rectangular cut-outs, drill a series of small holes around

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	8	1MΩ	brown black green brown	brown black black yellow brown
❑	8	47kΩ	yellow purple orange brown	yellow purple black red brown
❑	5	10kΩ	brown black orange brown	brown black black red brown
❑	9	1kΩ	brown black red brown	brown black black brown brown
❑	4	100Ω	brown black brown brown	brown black black black brown
❑	8	22Ω	red red black brown	red red black gold brown

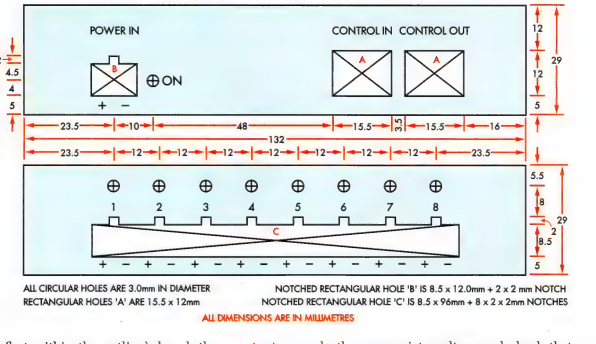


Fig.5: the drilling template and panel labels for the front panel (top) and rear of the case (bottom). These can be photocopied or downloaded as a PDF from the SILICON CHIP website and printed out. Print them onto transparency film or print onto paper and laminate them to make durable labels.

the outside of each (but within the outline), knock the remainder out and then file the edges smooth. For the largest cut-out, use a large flat file to start with and then needle files to finish the corners. The smaller cut-outs can be shaped entirely with needle files. Go slowly since it's easy to make holes too big in the soft plastic.

Check that the PCB connectors fit through the holes and then test fit the pluggable terminal blocks. If one doesn't fit, the notch may need to be enlarged. Then remove the drilling templates and prepare panel labels. These can be laminated paper or labels printed onto transparency film. Cut out the holes using a sharp knife and then glue the labels in place.

The bottom of the case has eight moulded plastic posts. The PCB attaches to the four outer ones but the inner posts would interfere with solder joints so remove them using side-cutters or a file. Then fit the panels at both ends of the PCB and lower the assembly it into the case, fixing in place with four self-tapping screws.

Plug in the nine terminal blocks and attach the lid and the unit is complete.

Testing

Apply 12V or so to the supply connector, observing the marked polarity. The green LED should light. Check that the current draw is around 15mA. If it is significantly more then switch off and check the board for faults.

Connect the slave's control input to the master unit and play the test sequence (see the Digital Lighting Controller articles, October-December 2010). With the slave powered up, the red LEDs should show the expected patterns. Ensure that they all light and that their brightness varies correctly.

Don't forget to set up the DC slave in the configuration file. Assuming this is the first/only slave attached, it should contain these lines:

```
triac turnoff 1 = delayed
slave type 1 = DC
```

You can then remove power, attach LED strings to the outputs, supply the appropriate voltage and check that everything is working as expected.

Using it

For reliable operation, ensure that the current ratings are not exceeded. These are specified as RMS figures since the light output will be constantly changing. The peak current can briefly exceed these limits.

While each channel can deliver 2.5A RMS, the incoming supply current is limited to 10A RMS and so you can't drive all eight channels at this current simultaneously (8 x 2.5A = 20A). If the total driven LED current can exceed 10A, be careful that it only does so briefly if at all.

The fuse limits the peak supply current. While a 10A fuse will not blow immediately at say 15A, repetitive excursions far above its rated current can weaken the fuse wire and eventually lead to failure. A slow-blow fuse provides more leeway.

Even so, it's best to keep the peak current to a reasonable value (say, about 15A for one second) to avoid overheating and damaging the PCB tracks.

RGB LEDs

As well as single-colour LEDs, the LED slave can be used with common anode RGB LED strips (eg, Jaycar ZD-0478). Connect the three cathodes (red, green and blue) to the negative output terminals of separate channels (ideally, consecutive channels). Connect the common anode to any of the three corresponding positive outputs.

The sequence then determines the colour of the LEDs; by turning two or three outputs on at once, with varying brightness, a wide range of colours can be produced. The PC software can be configured to display the channels as red, green and blue as appropriate (see the December 2010 issue for more information on how to use this software).

Since each RGB LED strip takes up three channels, you can drive up to two strips with a single slave (leaving two spare channels), five strips from two slaves (with one spare channel), eight strips from three slaves and ten strips from four slaves (with two spare channels). SC

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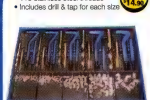

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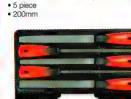

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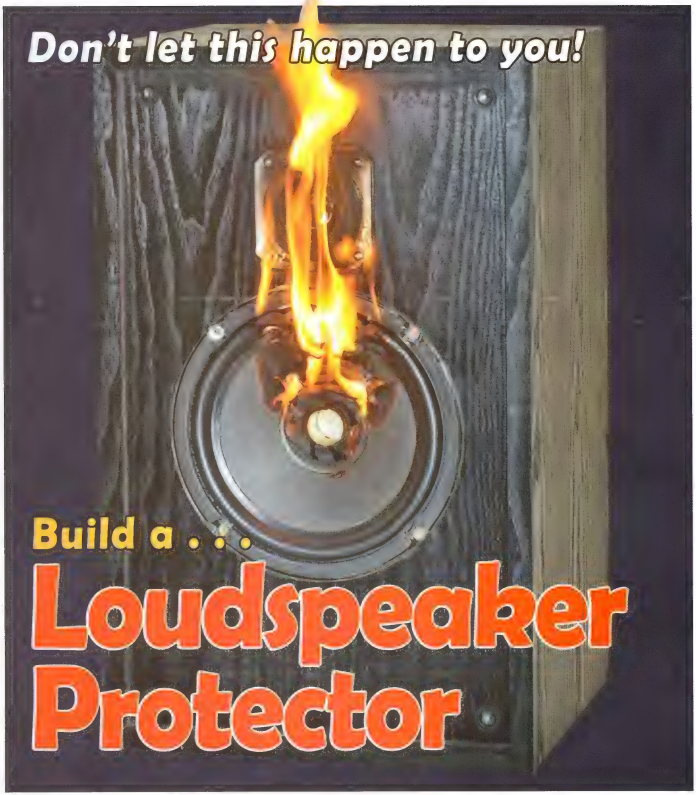


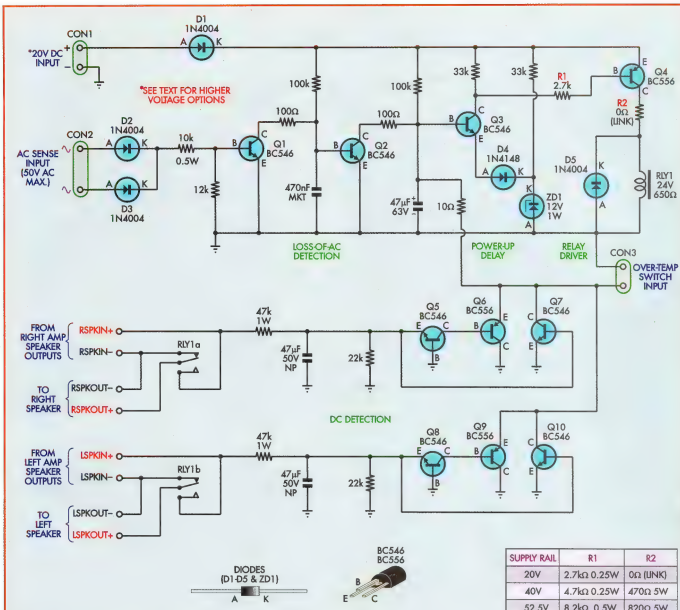
Build a . . .

Loudspeaker Protector

THE SPEAKER in the above photo is well on fire and this could be the result of a relatively minor fault in an audio amplifier. As anyone who has been following our series on the Ultra-LD Mk.3 Amplifier would be well aware, big power amplifiers have big power supplies and so a relatively minor fault in one channel of a stereo amplifier can result in a large DC voltage being applied to one of your precious (and expensive) loudspeakers.

Once that happens, your speaker is kaput! If you're lucky, the woofer's voice coil will quickly burn out and that will be the end of it – it's unlikely that the amplifier's fuses will blow in time to save your loudspeaker. You will then probably have to scrap the loudspeaker although if you are lucky and if it is economic, you might be able to have it repaired.

But you might not be that fortunate and the consequences could be a



SUPPLY RAIL	R1	R2
20V	2.7kΩ 0.25W	0Ω (LINK)
40V	4.7kΩ 0.25W	470Ω 5W
52.5V	8.2kΩ 0.5W	820Ω 5W
57V	8.2kΩ 0.5W	1kΩ 5W
70V	12kΩ 1W	1.2kΩ 10W

SC 10021 SPEAKER PROTECTION & MUTING

Fig.1: each channel of the amplifier is monitored for DC faults by three transistors – Q5-Q7 for the right channel & Q8-Q10 for the left. If DC is detected, these pull Q3's base low which then turns off Q4 and the relay to disconnect the speakers. Q1 & Q2 provide the switch-off muting feature, while CON3 accepts a normally-open temperature switch.

whole lot worse. Now, instead of suddenly burning out, the voice coil stays intact and gets red-hot, as you would expect it to – it is dissipating many hundreds of watts. After all, voice coils are quite small and they normally operate in the very confined space of the speaker magnet's voice coil gap.

With a large DC fault voltage across the voice coil, the speaker will either jump forward out of the gap or jump back as far as it can go. The latter is probably the worse scenario since the voice coil can then get even hotter and soon sets the speaker cone on fire.

The sequence of photos shown elsewhere in this article show how the whole speaker cone can catch fire within just a few seconds. A few seconds later and those flames were producing copious amounts of smoke. If we hadn't been on the spot to put the fire out by laying the speaker face down on the concrete, the fire could have spread to who knows where.

If that happened in your home and you were not present to take very quick action, you could lose your home and everything in it.

This sort of thing really can and does happen! Don't let it happen to your stereo system. This loudspeaker protector and muting circuit can prevent such disasters.

Main features

Originally designed for the Class-A Stereo Amplifier described in the June-September 2007 issues of SILICON CHIP, the 2-channel loudspeaker protector described here (in slightly modified form) is also eminently suitable for use with the new Ultra-LD Mk.3 Amplifier module. In fact, it can be used with just about any audio amplifier,

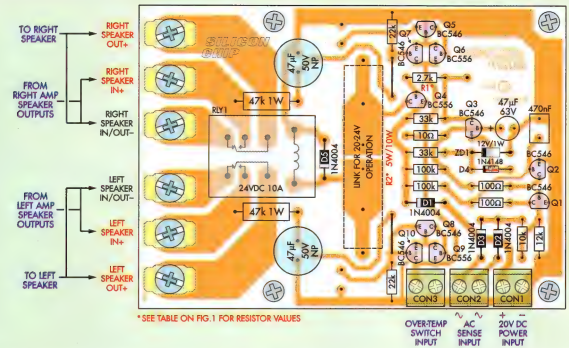


Fig.2: follow this layout diagram to install the parts on the board. Note that the final version of the PCB supports both double-ended spade connectors (attached using M4 screws & nuts – see Fig.3) and the solderable PC-mount vertical spade connectors as shown in the photo. Refer to the table on Fig.1 for the values of resistors R1 & R2.

either mono or stereo. It provides the following functions:

(1) it protects the loudspeakers against catastrophic failure in the amplifier, eg, if an output transistor goes short circuit or one supply fuse blows;

(2) it provides muting at switch-on and switch-off, to prevent thumps from the loudspeakers; and

(3) it provides an input for an over-temperature switch to disconnect the loudspeakers if the output stage heatsink rises above a certain temperature.

In the latter case, disconnecting the loudspeaker from a class-B amplifier immediately reduces the current through the output stage to the quiescent current setting. This is typically around 50-200mA, assuming that there's no fault in the amplifier.

So for a class-B amplifier, it makes sense to use over-temperature sensing. If the heatsink to which the output transistors are attached gets too hot, disconnecting the loudspeaker immediately reduces the dissipation to just a few watts, which allows the heatsink to cool.

Protecting against fire

As mentioned at the start of this article, by far the biggest reason for incorporating speaker protection into an amplifier is to prevent further damage and possible fire in the case of a serious amplifier fault. In the Ultra-LD Mk.3 Amplifier, the main supply rails are ±57V DC. As a result, if an output transistor fails (or if one side of the output stage turns hard-on due to a fault elsewhere in the amplifier) and there's no loudspeaker protection, this could apply one of the full 57V DC rails to the loudspeaker.

If the on-board supply fuse didn't blow fairly quickly (a strong possibility), the voice coil would quickly become red-hot. This risk applies to any audio power amplifier of more than about 40W per channel.

Muting the thumps

Muting switch-on and switch-off thumps is another important function of this unit.

Switch-on thumps are eliminated by using a simple circuit to delay the

Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	47kΩ 1W, 5%	yellow violet orange gold	not applicable
❑	2	33kΩ	orange orange orange brown	orange orange black red brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	1	12kΩ	brown red orange brown	brown red black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.7kΩ	red violet red brown	red violet black brown brown
❑	2	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown

relay from turning on when power is first applied. This allows the amplifier modules to power up and settle down before the relay switches on (after about five seconds) to connect the speakers.

By contrast, switch-off thumps are eliminated by using an "AC Sense" input to monitor the secondary AC voltage from the transformer (30VAC in the case of the Ultra-LD Mk.3 and up to 50VAC maximum). When this AC voltage disappears at switch-off, the circuit switches the relay off in less than 100ms.

This is much faster than simply relying on the collapsing DC supply rail to turn to the relay off. In practice, this could take 0.5 seconds or more as the main filter capacitors discharge – more than long enough for any switch-off thumps to be audible.

Circuit details

Refer now to Fig.1 for the circuit details. It's virtually the same as the circuit published in July 2007 with just a couple of minor modifications. We'll come to those shortly.

As shown, each channel of the amplifier is connected to the NC & NO (normally closed & normally open) contacts of a relay. The relay wipers and NC contacts then each respectively connect to the positive and negative loudspeaker terminals.

Each channel of the amplifier is monitored for DC faults by a triplet of transistors – Q5, Q6 & Q7 for the right channel and Q8, Q9 & Q10 for the left channel. We'll look at the operation of the right channel only, as the circuit for the left channel is identical.

As shown, the active signal from the amplifier's right channel is fed to a low-pass filter consisting of a 47kΩ resistor and a 47µF 50V bipolar (BP or NP) electrolytic capacitor. The original circuit used a 2-pole filter consisting of two 22kΩ resistors and two 47µF bipolar capacitors in this position but we've modified it to a single-pole filter to achieve a faster response – see panel.

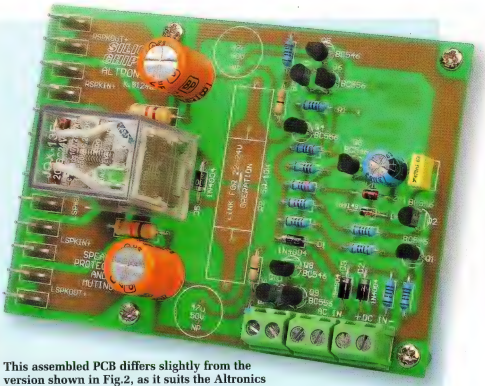
The low-pass filter network removes any audio frequencies so that transistors Q5-Q7 simply monitor the output of the amplifier for DC voltages (if present under fault conditions). This is done because we don't want audio signals to trip the protection circuit.

The low-pass filter output is connected to the emitter of Q5 and to the base of Q7. Q5 monitors the amplifier's output for negative DC signals while Q7 monitors for positive DC signals.

In operation, Q7 turns on if a DC signal of more than +0.6V is present on its base. Similarly, Q5 turns on if a DC signal of more than -0.6V is present on its emitter. This in turn pulls Q6's base low and so Q6 also turns on.

Normally, in the absence of any amplifier faults, transistors Q5-Q7 are all off and Q3 is biased on via the 100kΩ resistor connected between its base and the positive supply rail (ignore Q1 & Q2 for the time being). As a result, Q3 pulls Q4's base down (via resistor R1) to just over 12.6V, as set by diode D4 and zener diode ZD1, and so Q4 and relay RLY1 are also on.

Now let's consider what happens



This assembled PCB differs slightly from the version shown in Fig.2, as it suits the Altronics PC-mount vertical spade connectors.

Modifying The Circuit For A Faster Response

As stated in the main article, we modified the original Loudspeaker Protector circuit published in July 2007 to reduce the switch-off delay in the event of an amplifier fault. This was done by removing one of the two cascaded RC low-pass filters at each input, which means that the circuit now uses single-pole filters instead.

In practice, this simply involved removing a 22kΩ resistor and a 47µF bipolar capacitor from both the left and right inputs and replacing the resistors with wire links. The filter corner frequency is essentially unchanged as the resistor value in the remaining filter in each channel is doubled from 22kΩ to 47kΩ.

The logic behind the original 2-pole filter was that the -12dB/octave slope allowed a higher -3dB point than is possible with a single-pole filter (-6dB/octave). This should provide a faster response to DC faults while preserving the necessary large amplitude bass signal rejection. However, this ignores the 2-pole filter's larger phase shift of 180° rather than 90°. The delay created by this phase shift more than offsets the benefit from the higher corner frequency!

According to Douglas Self, the single-pole filter has a 78ms response time, compared to 114ms for the 2-pole filter (see *Audio Power Amplifier Design Handbook*, Fifth Edition, Chapter 17: "Amplifier and Loudspeaker Protection"). That does not include the relay switching time, which will be around 10ms. But it is clearly a worthwhile improvement and also reduces the parts count and the cost.

So making the change is a "no-brainer".

Temperature Sensors

Temperature sensors are variously called "thermostat switches", "thermal cutouts" and "thermal circuit breakers" and are available in a range of trip temperatures from 50-100°C. Both NO and NC (normally-closed) temperature sensors are available but the temperature sensor used with this unit must be a *normally open (NO)* type.

A thermal cutout rated at 70°C (eg, Jaycar ST3831) is suitable for the Ultra-LD Mk.3 amplifier (and for earlier versions of this module). Alternatively, use the Altronics S5591 which is rated at 60°C.

if an amplifier fault condition results in DC being present at its output. In this case, either Q6 or Q7 turns on and pulls Q3's base low via a 10Ω resistor. And when that happens, Q3, Q4 and the relay all immediately turn off, disconnecting the speakers.

Diode D5 protects Q4 by quenching any back-EMF spikes that are generated when the relay switches off.

Transistors Q8, Q9 and Q10 monitor the left channel of the amplifier and they switch Q3, Q4 and the relay in exactly the same manner.

Relay specifications

The relay selected for the job is a 24V DC DPDT type with contacts rated at 10A. There are two reasons for this high contact rating. First, we want the contact resistance in the relay to be as low as possible so that it has negligible effect on the amplifier's performance, as regards to distortion, damping factor and so on.

Second, the relay contacts have to pass and break the heavy DC current which would otherwise flow through the loudspeaker if a fault occurs in the amplifier. However, we don't merely use the relay to disconnect the amplifier's output from the speakers. If we simply did this, it's possible that the contacts would just arc across and so the heavy DC current would continue to flow through the loudspeaker.

That might seem unlikely but when you have a heavy DC current, an inductive load and a high DC voltage pushing it along, it can be quite hard to break the circuit. This problem is solved by shorting the moving relay contacts to the loudspeaker ground lines (via the otherwise unused NC contacts) when the relays turn off. This diverts the arc current to chassis and ensures that the fuses blow on the amplifier.

By the way, the specified relay (Altronics S-4313) has an in-built green LED that lights when the relay turns on. This lets you quickly check the status of the relay during testing but is not really necessary.

Muting delay at switch-on

Switch-on muting is achieved using a delay circuit. This consists of a 100kΩ resistor and a 47μF capacitor connected to Q3's base, along with diode D4 and zener diode ZD1.

When power is first applied, the 47μF capacitor is discharged and Q3's base is held low. As a result Q3, Q4 and the relay all remain off. The 47μF capacitor then charges via the 100kΩ resistor until, after about five seconds, it reaches 13.2V. This forward biases Q3 which then turns on Q4 and the relay to connect the loudspeakers.

This 5s delay is more than sufficient for the amplifier modules to achieve stable operating conditions.

Switch-off muting

Transistors Q1 & Q2 and diodes D2 & D3 provide the switch-off muting function.

D2 & D3 rectify the AC voltage that's fed to the "AC Sense" input (at connector CON2) from a transformer secondary winding. Provided this AC voltage is present, the rectified output forward biases Q1 and keeps it turned on. This holds Q2's base low and so Q2 is off and Q3 functions normally.

The 100kΩ resistor and the 470nF capacitor on Q2's base form a time constant. This is long enough to ensure that Q2 remains off when Q1 very briefly turns off around the AC zero crossing points.

However, if the AC signal ceases (ie, at switch off), Q1 immediately turns off and Q2 turns on and quickly discharges (within a millisecond or so) the 47μF timing capacitor via a 100Ω resistor. As a result, Q3, Q4 and the relay all turn off and the loudspeakers are disconnected, thereby eliminating any switch-off thumps.

Over-temperature input

Connector CON3 is the temperature sensor input. It relies on the use of a normally-open (NO) thermal switch that's bolted to the heatsink used for the amplifier's output transistors.

Basically, this input is wired in parallel with transistors Q6 & Q7 (and Q9 & Q10) and it controls transistor Q3 in exactly the same manner.

When the temperature reaches a preset level (set by the switch itself), the contacts inside the thermal switch close and pull Q3's base low via a 10Ω resistor. As a result, Q3 turns off and this switches off Q4 and the relay.

When the heatsink subsequently cools down, the thermal cutout opens again and Q3, Q4 and the relay turn on to reconnect the loudspeakers.

In a stereo amplifier, two identical temperature sensors are used – one for each heatsink (assuming the power amplifiers use separate heatsinks). These are simply wired in parallel and connected to CON3.

Power supply

Power for the Loudspeaker Protection circuit is derived from a suitable DC rail within the amplifier. This can range anywhere from about 20V DC up to 70V DC.

In the case of the Ultra-LD Mk.3 Amplifier, the +20V and 0V rails from the power supply board are used. The "AC Sense" signal is picked up directly from the AC terminals on the bridge rectifier on the same board.

Note that the values shown for R1 & R2 on Figs.1 & 2 assume a 20-24V supply rail. If the DC supply rail is higher than this, then resistors R1 and R2 must be changed to ensure a base current of about 3-5mA for Q4 (as set by R1) and to ensure that no more than about 24V DC is applied to the relay (set by R2). In the latter case, it's just a matter of selecting R2 so that the relay current is about 37mA (the relay has a coil resistance of about 650Ω).

The table included with Fig.1 shows the resistor values to use with a number of supply rails.

Building it

The parts for the Speaker Protection & Muting Module are all mounted on a PCB coded 01207071. This board is the

Attaching The Spade Lug Connectors

Fig.3 (right) shows how the double-ended spade lugs are mounted. Each lug is secured using an M4 x 10mm screw, a flat washer (which goes against the PC board pad), an M4 star lockwasher and an M4 nut.

The trick to installing them is to first do the nut up finger-tight, then rotate the spade lug assembly so that it is at a right-angle to the PC board. A screwdriver is then used to hold the M4 screw and the spade lug stationary while the nut is tightened from below using an M4 socket and ratchet.

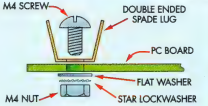


Fig.3: attach the six double-ended spade lugs to the PCB as shown in this diagram.

Do the nut up nice and tight to ensure a good connection and to ensure that the assembly does not rotate.

same as the one used in July 2007 – it's simply a matter of leaving out the two unwanted capacitors and installing a couple of wire links (or 0Ω resistors) in place of the deleted 22kΩ resistors. The other two 22kΩ pull-down resistors (to the left of Q5 and to the left of CON3) remain in circuit.

Fig.2 shows the revised PCB layout. Mount the resistors and diodes first, taking care to ensure that the diodes are all oriented correctly.

Install a 2.7kΩ 0.25W resistor for R1 and a link for R2 if you are building the unit for the Ultra-LD Mk.3 Amplifier. Alternatively, select these resistors from the table shown in Fig.1 if you intend using a supply rail greater than 24V.

If the supply rail is between the values shown in the table, simply scale the resistor values accordingly and use the nearest preferred value.

The six double-ended spade lugs for the speaker input and output terminals are attached using M4 x 10mm screws, flat washers, star washers and nuts. Fig.3 shows the details.

Note that, ideally, the double-ended spade lugs supplied should be 90° types. If you are supplied with 45° types, just bend the lugs to 90° before installing them on the board.

Alternatively, the final version of the PCB will also have provision to accept 6.3mm PC-mount vertical spade connectors (Altronics H2094), as shown in the photo.

The transistors, the electrolytic capacitor and the bipolar capacitors can now be installed. The two 47µF bipolar capacitors can go in either way around but watch the orientation of the polarised 47µF 63V electrolytic capacitor.

Finally, you can complete the board assembly by fitting the three 2-way terminal blocks and the DPDT relay.

Testing

If you have a suitable DC supply, you can test the unit prior to installing it. To do this, connect the supply to CON1 and install a wire link between one of the CON2 "AC Sense" input terminals and the positive supply rail (this is done to ensure transistor Q1 turns on). Do not connect anything to the temperature switch input or to the speaker terminals at this stage.

Next, apply power and check that the relay turns on after about 5s. If it does, temporarily short the temperature switch input – the relay should immediately switch off.

Similarly, the relay should immediately switch off if you disconnect the link to the "AC Sense" input.

The next step is to check that the relay switches off if a DC voltage is applied to the loudspeaker terminals (this simulates an amplifier fault condition). To do this, apply power, wait until the relay switches on, then connect a 3V (2 x 1.5V cells in series) or 9V battery (either way around) between the ground (-) terminal of CON1 and the LSPKIN+ terminal. The relay should immediately switch off.

Repeat this test for the RSPKIN+ terminal, then reverse the battery polarity and perform the above two tests again. The relay should switch off each time the battery is connected.

Note that we don't connect to the LSPKIN- or RSPKIN- terminals for this test because these two inputs are fully floating at this stage. That changes when the Speaker Protector module is installed in a chassis and the loudspeaker leads are connected, because the negative loudspeaker terminals on the amplifier are connected to chassis (via the power supply).

Parts List

1 PCB, code 01207071, 112.5mm x 80mm
1 10A 24V DPDT PC-mount relay (Altronics S-4313)
3 2-way 5mm or 5.08mm pitch terminal blocks (CON1-CON3)
4 M3 x 10mm tapped spacers
4 M3 x 6mm pan head screws
6 M4 x 10mm pan head screws
6 M4 flat washers
6 M4 shakeproof washers
6 M4 nuts
6 6.3mm double-ended 45° or 90° chassis-mount spade lugs (Altronics H-2261, Jaycar PT-4905) OR 12 x 6.3mm PC-mount vertical spade connectors (Altronics H2094)
0.7mm diameter tinned copper wire for links

Semiconductors

7 BC546 NPN transistors (Q1-Q3, Q5, Q7, Q8 & Q10)
3 BC556 PNP transistors (Q4, Q6 & Q9)
4 1N4004 diodes (D1-D3, D5)
1 1N4148 diode (D4)
1 12V 1W zener diode (ZD1)

Capacitors

1 47µF 63V PC electrolytic
2 47µF 50V non-polarised (bipolar) electrolytic (Altronics R-6580, Jaycar RY-6820)
1 470nF 50V metallised polyester (MKT)

Resistors (0.25W, 1%)

2 100kΩ	1 10kΩ 0.5W
2 33kΩ	1 2.7kΩ
2 22kΩ	2 100Ω
1 12kΩ	1 10Ω
2 47kΩ 1W 5%	

Troubleshooting

If the relay doesn't activate when power is applied, switch off immediately and check for wiring errors, eg, incorrect supply polarity, a transistor in the wrong location etc. If this doesn't locate the fault, switch on and check the supply voltage, then check the voltages around the transistors.

Setting The Loudspeaker On Fire

These three photos, taken at 3-second intervals, illustrate just how quickly the fire takes hold once the cone ignites.

To obtain the sequence of photos for this article, we engaged in some deliberate vandalism! To simulate what can happen when a DC fault occurs in a big stereo power amplifier, we actually connected the nominal 57V DC rail of our prototype power supply for the Ultra-LD Mk.3 power amplifier to a loudspeaker. This power supply employs a 300VA transformer and while its continuous rating is 300VA it can deliver a lot more than that in the short term.

If you get a DC fault in a power amplifier, the normal result is that it applies the full DC supply (positive or negative) to the loudspeaker. You cannot rely on the amplifier fuses to blow quickly; to blow quickly, they need to carry a current which is two times their rating or more.

As preparation for this staged disaster we first connected one of the 57V rails across an 8-ohm resistive load. Under these conditions, the supply dropped to about 47V. This means that 276W was dissipated in the load; quite enough to cause a fire in the wrong circumstances. And note that the fault current of 5.9A would definitely not blow the on-board 6.5A fuses in the Ultra-LD Mk.3; they will happily run all day with that current.

We then measured the DC resistance of the loudspeaker victim (actually the Minstrel 2-way 8-inch loudspeaker we described in the February 1989 issue). It was about 7.6Ω. Again, doing the calculations, a DC fault in the Ultra-LD could be expected to deliver almost 300W into the 25mm voice coil of the poor unsuspecting loudspeaker.

We duly set up the test with the loudspeaker on a stand and with cameras at the ready, one of them being set to video the event. After a quick measurement, we switched on the fault. This produced a loud click from the loudspeaker and the cone jumped out about 2cm; probably to the limit of suspension travel. There was a fairly pronounced hum for a few seconds and then silence.

Bugger! The voice coil had obviously burnt out! We quickly felt around the front of the voice coil dust cap and noted that it was quite hot and also had a distinct burning smell.

Well that was that but we still needed some photos to demonstrate what can really happen if the voice coil stays intact for just a bit longer. Being ever resourceful (and using generous journalistic licence), we just happened to have a propane gas lighter handy. We lightly touched its very small flame to the speaker's cone, just below the dust cap. It was already so hot that it immediately caught fire and within seconds the whole cone was well alight with lots of flame and smoke, as can be seen in the sequence of photos.

Within just a few seconds more, this would be enough to set a whole room alight with really dire consequences for anyone in the house. Need we say more.

Do not imagine for a moment that this sort of thing cannot happen to you. In fact, our calculations show that the bigger the power amplifier, the more risk of a catastrophic fire if the amplifier does not have an in-built loudspeaker protector to disconnect the speakers in the case of a DC fault.

After we had extinguished the fire by putting the loudspeaker face down onto the concrete in our company parking area, we took some additional photos which showed that the bonded acetate fibre filling behind the speaker had been already alight. When this stuff burns it produces copious quantities of thick black acrid smoke. Enough said.

Q3's emitter should be at about 12.6V and its collector at 12.8V, while both Q3 and Q4 should have base-emitter voltages of 0.6V.

Similarly, Q1 should have a base-emitter voltage of 0.6V (provided the link between the "AC Sense" Input and the positive supply terminal is in place) but transistors Q2 & Q5-Q10 should all be off – ie, they should have base-emitter voltages of 0.2V or less.

If Q3's base voltage is low (around 0.2V), it could mean that Q2 is on and Q1 is off, possibly due to no voltage being applied to Q1's base. Alternatively, one of the transistors in the speaker input monitoring circuits (ie, Q5-Q10) could be faulty (short circuit).

You can quickly isolate which circuit section is at fault by disconnecting the 10Ω and 100Ω resistors to Q3's base.

Just remember that all transistors that are turned on will have a base-emitter voltage of about 0.6V. This should enable you to quickly locate where the trouble lies. SC

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PRODUCT SHOWCASE

MDO-4000: world's first mixed-domain scope from Textronix

Tektronix have introduced the world's first Mixed-Domain Oscilloscope Series – 'scopes with a built-in spectrum analysers.

The MDO-4000 is the first oscilloscope to correlate the analog, digital and RF domains. All other oscilloscopes use FFT to convert data from the analog input channels but the MDO4000 is unique in having a separate RF input with higher dynamic range.

It can also be used as a stand-alone spectrum analyser for many applications.

For the first time, you can capture time-correlated analog, digital and RF signals for a complete system view of your device and see both the time and frequency domain in a single glance; view the RF spectrum at any point in time to see how it changes with time or device state and solve the most complicated design issues, quickly and efficiently, with an oscilloscope as integrated as your design.

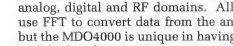
There are four models in the MDO-4000 range, two 500MHz 2.5GS/s and two 1GHz, 5GS/s. All offer four analog and 16 digital channels, a 20M record length, 1 RF channel and either 3 or 6GHz top frequency.

Contact:
TekMark Australia Pty Ltd
Suite 302, 18-20 Orion Rd Lane Cove NSW 2066
Tel: (02) 9911 3888 **Fax:** (02) 9418 8485
Website: www.tekmarkgroup.com

SEE REVIEW NEXT MONTH!

SILICON CHIP is currently preparing a comprehensive review of the MDO-4000 – we plan to publish this in the NOVEMBER issue.

Colour-dimmable LEDs



Too late for inclusion in our LED feature last month, these LEDs can be "dimmed" to change their colour temperature to suit the occassion, from 2200 to 12000K (warm red to cool).

Contact:
SAN TY Group Ltd
A18, 4F, JiaLe Bldg, Yan Nan Rd, Shenzen, China.
Tel: +86 (755) 8254 0018 **Fax:** +86 (755) 8254 0028
Website: www.santygroup.com

Cabinet Temperature Sensor

Often in commercial and industry situations the internal temperature of cabinets and rooms containing computer equipment, motor drives, switchgear and telemetry equipment needs to be monitored. The KTA-267 is a simple 4-20mA output loop powered temperature sensor with a measurement range from -10°C to +125°C. The 4-20mA signal can be easily connected to a control or monitoring device such as a PLC or GSM/GPRS RTU. With an area of just 72 x 20mm it can easily be fitted into a cabinet.

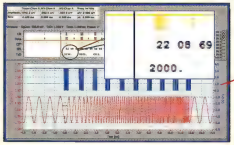
Priced from $44.95+GST, it can be purchased as a card which can be mounted on spacers or fitted with a DIN Rail mount.

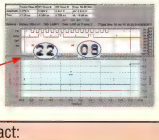
Contact:
Ocean Controls
PO Box 2191, Seaford BC, VIC 3198
Tel: (03) 9782 5882
Website: www.oceancontrols.com.au

Cleverscope adds deep memory protocol decoding with zoom

Cleverscopes' protocol decoder for the CS328A Oscilloscope decodes digital data streams up to 4 MSamples long. Results are displayed right on the mixed signal graph, lined up with the digital and analog source signals. The tool is great for checking the operation of SPI, I²C, RS232 or bus-based products.

The example shows an AD9834 synthesiser being exercised. You can zoom right in to check signal integrity and timing with 10ns resolution.





The decoder is fully configurable for bit length, polarity, and colours. Using the 10ns resolution trigger time stamp you can precisely measure widely spaced packets.

Navigating the captured signal is fast and easy; the zoomed Tracking graph follows the Scope graph tracer to see the big picture and the detail simultaneously.

Contact:
Cleverscope Ltd
128 Ranfurly Rd, Epsom, Auckland NZ
Tel: +64 (9) 524 7456 **Fax:** +64 (9) 524 7457
Website: www.cleverscope.com

Switchmode: Australia's only power supply specialist

Switchmode Power Supplies is unique, in that it is the only organisation in Australia that specialises solely in the repair, refurbishment and calibration of power supplies.

Founded in 1984 by the current Managing Director, Martin Griffith (ex RAAF Radtech and RMIT graduate), Switchmode has continually maintained the strategy to provide maintenance services for high end equipment at their Hornsby workshop.

Advocates of workmanship in accordance with and in excess of industry standards, Switchmode boasts quality certification to ISO9001, a NATA accredited laboratory with ISO17025 and compliance with a long list of Australian National, International, NASA and Mil Standards.

Switchmode's library of over 5500 hardcopy files includes technical information, failure analysis, repair flow charts, BOMs and schematics from more than 1000 different manufacturers. In addition and readily accessible to their Technicians on database they have softcopy including shadowmask locations and the nature of failure of every electronics component, every resistor, capacitor and semiconductor found to have failed over the last twenty years.

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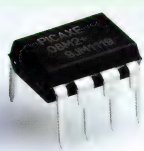
New "M2" PICAXEs from Rev-Ed

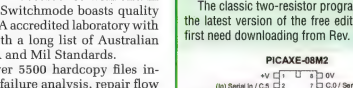


Revolution Education has recently released four new "M2" versions of their popular PICAXE microcontrollers. The 08,14,18 and 20 offer more speed, memory, features and lower supply needs.

Features and performance of these new chips are superior by almost an order of magnitude to existing models but prices remain essentially the same – the 8-pin M2, for example, is just $3.

The global PICAXE popularity has allowed Microchip to customise these new microcontrollers (based upon the 16F182x series PIC architecture) for Re-Ed – there's now even a laser engraved title on each chip!

The classic two-resistor programming set up is still used but the latest version of the free editor (Ver. 5.4.0 or greater) will first need downloading from Rev. Ed's site (www.picaxe.com).



Amongst the enhanced features of the M2 family are –

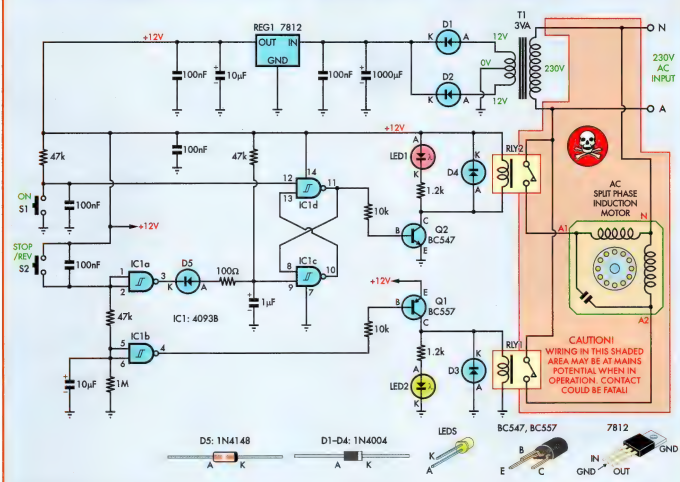
- Pin configuration – almost every pin on each size chip can now be assigned as an input or output
- Extra ADC channels, including support for capacitive touch sensing
- Serial input programming pins now can be used for extra inputs
- Enhanced applications and commands available for most pins-touch, I²C etc
- Support for multi-tasking, with four or eight separate tasks able to run in parallel.
- Much greater memory of 2048 bytes (~1800 program lines)
- Able to run on as low as 1.8V, allowing 2 x AA battery pack powering
- Up to 512 bytes of RAM with 28 general variables, plus 256 bytes of NV EEPROM
- Faster internal resonator, allowing speeds to 32MHz (default 4MHz)
- Support for such advanced features as DAC, SR latch, I²C and faster serial
- Inbuilt digital temperature sensor, accessed by "READINTERNALTEMP"
- Serial and IR timeouts, plus elapsed time measurement via the 'time' variable
- Backward compatibility with earlier PICAXEs

These new M2 microcontrollers effectively refine the PICAXE product range, and many of the regular variants (including the esteemed 08M and 18X) will now become obsolete. Australian PICAXE agent Microzed already has good stocks and chips are available via usual distributors. ***Stan Swan***

Contact:
Microzed
Unit 5, 10 Kabi Cct, Deception Bay Qld 4508
Tel: 1300 735 420 **Fax:** 1300 735 421
Website: www.microzed.com.au

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Substitute for AC motor reversing switch

This circuit was devised as a substitute for a failed AC motor switch. It can start the motor in forward or reverse mode, as required.

It is based around a pair of NAND gates which are configured as an RS (Reset/Set) latch, with one input of each NAND gate cross-connected to the other gate's output. Hence, pin 12 of IC1d is the Set input while pin 9 is the Reset input. At power-up, the latch is reset because pin 9 of IC1c is initially held low by a 1µF capacitor. The capacitor charges up via a 47kΩ resistor and subsequently pulls pin 9 high.

Switch S1 is the start switch. Pressing it pulls pin 12 of IC1d low. This sets the latch and pin 11 goes high, turning on transistor Q2 and relay RLY2. This applies 230VAC to the A1 terminal of the motor and so the motor runs in the forward direction.

Gates IC1a & IC1b form the reset circuit. Switch S2 functions as the Stop/Reverse switch. Pressing switch S2 momentarily pulls pins 1 & 2 high, so pin 3 goes low and pulls pin 9 low, via diode D5 and a 100Ω resistor. This resets the latch and relay RLY2 is deactivated.

Pressing and holding switch S2 provides the reverse mode. As well as resetting the latch as before, it pulls pins 5 & 6 of IC1b high and this sets pin 4 low, turning on transistor Q1 and relay RLY1 which applies 230VAC to reverse the motor. Diodes D3 & D4 clamp the back-EMF voltage when RLY1 & RLY2 turn off.

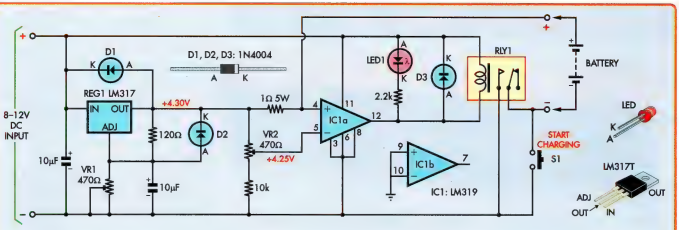
Switch S2 has to be held down to maintain the motor in reverse mode. Releasing the switch allows pins 5 & 6 is go low after a delay and relay RLY1 is deactivated to turn the motor off.

By that time, pin 9 of IC1c will have also gone high, pulled up by the 47kΩ resistor. The motor can then be started again in the forward direction, by pushing switch S1.

LED1 indicates the forward mode while LED2 indicates the reverse mode.

Michael Azzopardi,
Deer Park, Vic.

Michael Azzopardi is this month's winner of a Peak Atlas Test Instrument



Simple lithium-ion battery charger

This circuit is for charging lithium-ion batteries from cell phones and cameras where the original chargers are not available. These batteries are normally charged to 4.2V and the charging current gradually falls as full charge is approached. In this design, the battery is charged from 4.3V via a 1Ω 5W resistor.

Comparator IC1 compares the terminal of the battery being charged with a 4.25V reference, as set by VR2. When the charging current falls below about 50mA, the charge is terminated. This may not achieve full charge but it's close enough for most purposes. Charging is started by pressing S1. This connects one side of the battery to 0V and causes the comparator to turn on the relay, which holds the battery grounded until charging is switched off.

The input supply voltage is nominally 8-12V and is determined by the voltage required for the low power relay; it will also determine the degree of heatsinking required for the LM317 (REG1). The supply should be able to deliver around 2A.

The circuit employs an LM319 dual comparator which means that two batteries could easily be charged separately with an additional relay. LED1 indicates when charging is occurring.

The circuit is not intended as a fast charger (which may be an advantage with older batteries) and it may take several hours to charge a flat battery. Since these batteries should not be discharged below about 2.7V, care should be taken with any battery with a lower initial voltage.

There is no temperature monitoring of the batteries but this could be included by attaching a 10kΩ NTC (negative temperature coefficient) thermistor and connecting it in parallel with 470Ω trimpot VR1.

Finally, note that some lithium-ion should be charged to 3.6V (rather than 4.2V). VR1 and VR2 can be adjusted to suit these (ie, adjust VR1 for 3.7V at the output of REG1 and VR2 for 3.65V on pin 5 of IC1a).

Graham Jackman,
Oakleigh East, Vic. ($50)

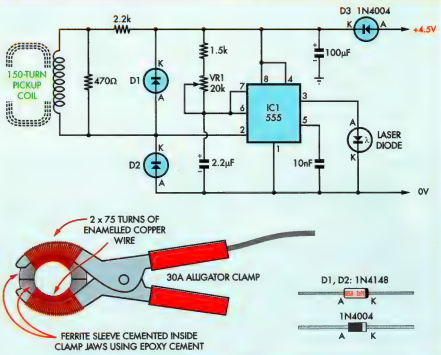
Timing laser for small 2-stroke motors

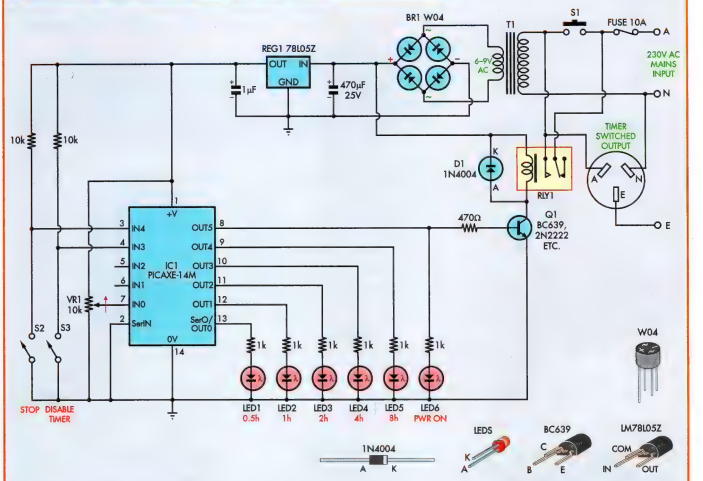
This circuit illuminates the timing marks (usually on the flywheel) at the firing of cylinder 1 in a 2-stroke motor. It should also work on cars.

The pick-up is made by winding about 150 turns of enamelled copper wire through a split toroid sleeve (eg, Jaycar LF1290) – see diagram. This is placed over the spark plug lead and the signal developed in the coil is used to trigger a 555 timer (IC1) which is wired as a monostable pulse generator. The laser diode is driven directly from pin 3 of IC1 and the pulse width is adjusted by trimpot VR1.

The laser diode can be sourced from a junked laser pointer.

Phillip Reynolds,
Coromandel Valley, SA. ($45)





Mains timer has no stand-by power

This timer can be used with "dumb" battery chargers, to prevent over-charging of power tools batteries and so on. It could also be used to run a soldering iron, so that it turns off even if you forget to do so. It consumes no power until activated and then runs the load for the specified period before switching the load and itself off.

The time delay is set in 30-minute increments using VR1. The time remaining is shown in half-hour increments with a 5-LED display (LED1-5). One pushbutton (S2) immediately switches the power off while another (S3) forces it to stay on indefinitely.

Mains-rated momentary pushbutton switch S1 powers up the timer by connecting transformer T1 to 230V AC when it is pressed. Microcontroller IC1, a PICAXE 14M, immediately brings its pin 8 output high, turning on NPN transistor Q1 and so drawing current through the coil of mains-rated relay RLY1. This shorts out pushbutton S1, latching the power on. This output pin also drives the power-on LED (LED6).

When the timer expires or switch-off button S2 is pressed, IC1 brings its pin 8 output low, de-energising the relay and so cutting power to the mains transformer and load entirely. Diode D1 absorbs the voltage spike generated by the relay coil's back-EMF when power to it is cut.

Potentiometer VR1 is connected across the 5V supply as a voltage divider and its wiper is connected to pin 7 of IC1 (IN0). The microcontroller uses its internal analog-to-digital converter to read the voltage and so determines the desired timing duration. The stop (S2) and disable timer (S3) pushbuttons are sensed by input pins 3 and 4 respectively, using 10kΩ pull-up resistors.

The time remaining is shown by a combination of the five time LEDs (LEDs1-5). For example, if the remaining time is 4.5 hours, the "4 hour" (LED4) and "1/2 hour" (LED1) LEDs are illuminated. These are driven from output pins 9-13 of IC1 (OUT0-OUT4) via 1kΩ current-limiting resistors.

Power for the micro is derived from the 6-9V AC secondary of the mains transformer via bridge rectifier BR1 and a 470µF filter capacitor. It is regulated to 5V by REG1 with its associated 1µF output filter capacitor.

The source code for the microcontroller can be downloaded from the Silicon Chip website (simple_mains_timer.bas).

David Eather,
Toowoomba, Qld. ($50)

Editor's note: as with all mains-based projects, great care must be taken with the housing, insulation and earthing to ensure safety.

Spring SALE

October 2011

MASSIVE CLEARANCE ITEMS & NEW PRODUCT ARRIVALS INSIDE!

CARAVAN/MARINE POWER SYSTEM KIT – 12V 160W SOLAR

The perfect entry level power system for caravans and boats. Includes everything to make a complete 12V house battery system with enough stored battery power for short periods of free camping without AC power. Includes a Rich Electric CombiPlus 1500W-12V interactive inverter-charger, 2 x 80W monocrystalline solar panels, 150Ah AGM battery, dual battery isolator and most of the accessories required to complete out the system. See our website for full details and performance.

MP-9011

$4490.00

Also available:
Caravan/Marine Power System Kit - 12V 320W Solar **MP-9013** $6,445
Caravan/Motorhome/Marine Power System Kit - 24V 525W Solar **MP-9015** $9,979

HDMI AUDIO SIGNAL VOLUME LEVELLER

With advanced HDMI repeating and decoding, this HDMI Volume Leveller is the perfect choice to fine-tune your listening experience. It protects your home theatre equipment from noise spikes and will even sort out those annoying fluctuations in volume while channel surfing or between the TV shows and the advertisements.

- Regulates TV, satellite, radio & DVD volume
- Mains power supply included
- HDMI in/out ports
- Boosts low & high-frequency content dynamically
- Dimensions: 100(W) x 70(D) x 20(H)mm

AC-1615

$149.00

More Audio Converters on page 2

2.4GHz DIGITAL WIRELESS PAN/TILT ZOOM CHILD MONITORING SYSTEM

Keep an eye on a room full of children and pan across to zoom onto any one of them. It operates interference-free on a 2.4GHz band which produce clear image transmission and can remotely pan or tilt the camera from the viewing monitor. Also useful in monitoring a swimming pool, retail showroom, or factory.

- 2.4GHz DIGITAL Wireless transmission
- Range: 100m line of sight
- CMOS colour image sensor (640 x 480 pixels)
- Camera pans 270°, tilts 120°
- High quality microphone & speaker
- 2.4" LCD colour monitor screen
- 2 times digital zoom
- 4 separate channels
- Includes power adaptor for both units
- Dimensions:
  Camera unit: 112(W) x 109(D) x 133(H)mm
  Monitor unit: 68(W) x 26(D) x 149(L)mm

QC-3638

$299.00

Spare 2.4GHz DIGITAL PTZ camera available separately **QC-3637** $199.00

38 CHANNEL UHF TRANSCEIVER

Featuring a 38 channel hand-held transceiver with up to 3km range. Perfect for camping, picnics in the bush, skiing and hiking trips. It also features an integrated LED torch so you can find your way home in the dark. Requires 3 x AAA batteries.

- Push to Talk (PTT) function
- Electronic volume control
- Scan channel, call tone and monitor functions
- Low battery alert
- Dimensions: 122(H) x 54(W) x 35(D)mm

DC-1008

$19.95

Hurry in while stocks last!

Buy 2 for $30 SAVE $9.90

1500VA LINE INTERACTIVE UPS WITH LCD

A wide array of protective features and gives the user the ability to monitor the status of the UPS through the backlit LCD and the intelligent power management software (included). The unit protects against low/over voltage, surges, short circuits and power overloads. In the event of mains failure, the UPS will switch to its battery (10-30 minutes back-up depending on the load).

- Output power: 1500VA
- 3 mains socket connections
- Line interactive with AVR
- Microprocessor control for high reliability
- RJ45 protection
- Dimensions: 337(L) x 192(H) x 116(W)mm

MP-5206 WAS $369.00

$249.00 SAVE $120

BIG SALE

NETWORK 4 CH DVR WITH 10" MONITOR & COLOUR CAMERA KIT

The package incorporates a H.264 DVR with built-in 10' LCD monitor and 320GB HDD, 2 indoor/outdoor CMOS 350TVL cameras with IR illumination for night viewing, 2 x 18m cables and power supplies. Recording can be started manually, by programming or by triggered alarm conditions. The main feature is the Smartphone support and the iPhone® app you can download from iTunes® to view live or recorded footage*. Monitoring may be done real-time on the monitor, LAN network, via internet or Smartphone. The DVR functions can be controlled by mouse or the IR remote control.

- Dimensions:
  DVR/Screen: 208(L) x 85(W) x 242(H)mm
  Camera: 115(L) x 45(H)mm

QV-3030 WAS $799.00

NOTE: *App is free for single use and may incur a charge for multi-user

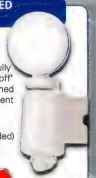
Additional Camera sold separately **QC-3239** $59.95

$699.00 SAVE $100

$20GB HDD Included!

BATTERY POWERED 2W LED SENSOR LIGHT

Easily mounts to any outdoor area and gives up to 180° of motion detection. The angle of the light and PIR detector are fully adjustable. With an adjustable "off" delay, the unit can be programmed to match any outdoor environment and needs.



- 1 x 2W high output LED
- 4 x C size batteries (not included)
- PIR detection range: 100-180°
- Power consumption: 600mA
- Dimensions: 95(L) x 240(H) x 137(D)mm

SL-2711

$49.95

See page 4 for Solar Powered Sensor Lights

TOWNSVILLE STORE RELOCATION

167 Ingham Road West End 4810

Ph: (07) 4772 5022

Parking Available!

Jaycar Electronics
Better, More Technical

Auto & Outdoors

38 CHANNEL UHF CB TWIN PACK

These mini UHF CB communicators (sold as a pair) can keep you clearly in touch with the kids at up to 3km range! Perfect for camping, picnics in the bush, skiing and hiking trips. Features an electronic volume control, monitor functions and an integrated LED torch. Comes in a child friendly package and supplied in orange and green units.

$39.95 SAVE $15

- 38 Channels
- Push to Talk (PTT) function
- Low battery alert
- Duplex range extender
- Requires 3 x AAA batteries per unit
- Dimensions: 55(W) x 110(H) x 35(D)mm

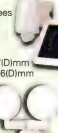
DC-1005 WAS $54.95

*Limited stock

CREE® SOLAR POWERED LED SENSOR LIGHTS

NEW 2011

Provide a very bright focused beam of light to illuminate your driveway, entry way or backyard. A waterproof solar panel with a 5m lead is supplied to keep the rechargeable batteries topped up. Each unit has a built-in PIR motion detector, which automatically turns the light on from an adjustable period of 5 to 20 seconds. A fully self sustained lighting kit perfect for applications where mains power is unavailable.



- Battery: Ni-MH battery
- Detection range: 100-180 degrees
- Detection distance: 8 metres

1 x 3W

- Dimensions: Solar light: 95(L) x 240(H) x 137(D)mm Solar panel: 140(L) x 198(H) x 66(D)mm

SL-2707 $99.00

2 x 3W

- Dimensions: Solar light: 205(L) x 242(H) x 135(D)mm Solar panel: 140(L) x 198(H) x 66(D)mm

SL-2709 $129.00

FROM $99.00

5 AMP CAR NOISE FILTER

Reduced noise and interference entering into your car stereo. Encapsulated in a compact case. 150mm leads for connection.

- Dimensions: 63(L) x 31(D)mm

AA-3072 WAS $15.95

$9.95 SAVE $6

Also available: 20 Amp Car Noise Filter **AA-3076** WAS $24.50 NOW $14.50 SAVE $10.00

SOLAR POWERED ALARM CLOCKS

Solar Powered LCD Calendar Alarm Clock

This functional timepiece features a crisp LCD time, calendar and temperature display. It also has a dual alarm with snooze button and a solar cell for auxiliary power.

- 12/24 hour time & °C/°F temp
- Requires 2 x AAA batteries
- Dimensions: 80(L) x 41(W) x 152(H)mm

XC-0213 WAS $19.95

$14.95 SAVE $5

Solar Powered Alarm Clock with Laser Projection

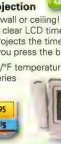
BIG SALE

Project the time on your wall or ceiling! A matt-silver finished alarm clock with clear LCD time, calendar and temperature display. It projects the time when the alarm goes off or when you press the button.

- 12/24 hour time and °C/°F temperature
- Requires 2 x AAA batteries
- Dimensions: 165(L) x 35(W) x 110(H)mm

XC-0214 WAS $24.95

$19.95 SAVE $5



3W LED TORCH/LANTERN COMBO

If you're heading into the wilderness, a torch that can be configured as a lantern is an incredibly useful tool. Features a powerful 140 Lumen convex LED for maximum light spread, multiple light modes, & a rotatable metal hook for hanging in your tent or around the campsite.

- Power: 3W
- Light modes: Low, High, Flashing
- Water resistant
- Batteries: 4 x AA (not included)
- Dimensions: 153(L) x 62(D)mm

ST-3135

$29.95 NEW 2011

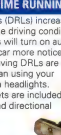
OUTDOOR FLAT PANEL UHF/VHF AMPLIFIED DIGITAL ANTENNA

With an integrated amplifier, it delivers local free-to-air analogue and digital TV as well as DAB+ digital radio programs. Also features waterproof and weather resistant ABS housing, low noise circuitry, multidirectional 360° reception and auto gain control. Includes mounting bracket, mains adaptor and coaxial cable.

- VHF Band III 174-230MHz
- UHF Band IV & V 470-862MHz
- Panel size: 281(W) x 305(H) x 20(D)mm

LT-3139 WAS $69.95

$49.95 SAVE $20



MAGNETIC PARKING SENSOR WITH BEEPER

When you get within 1m of another car or any other object near your bumper, the alarm will sound to alert you. Simple to install, the sensor is completely concealed under the bumper with no drilling required.

- Fits any vehicle
- Easy installation
- Connects to the reversing lights

LR-8861 WAS $49.95

$19.95 SAVE $30

VEHICLE LED DAYTIME RUNNING LIGHTS

Daytime running lights (DRLs) increases vehicle visibility during daytime driving conditions. These superbright LED bulbs will turn on automatically on ignition, making your car more noticeable on the road. These energy saving DRLs are a much better daytime alternative than using your fog lights or low beam headlights. Flush-mounted brackets are included for easy installation and directional tilt-adjustment.

$99.00 SAVE $50

- Energy efficient 12V 6.1W
- Emark 87R certificate
- Each lamp measures 190(W) x 30(H) x 43(D)mm

SL-3419 WAS $149.00

3CH VIDEO DISTRIBUTION AMPLIFIER FOR CARS

Ideal for automotive use and will let you share the video signal from your in-car video or DVD system. The built in amplifier ensures that all screens receive a full strength signal and produce best picture.

- Composite video input & output
- One input to three outputs
- Works with all in-car video screens
- 12VDC powered
- Dimensions: 63(L) x 32(W) x 30(H)mm

QC-3436 WAS $24.95

$19.95 SAVE $5

SURVIVOR DISTRESS STROBE LED LIGHT

A handy safety device when venturing out in open water. Unit is small, lightweight with a lanyard and clip for easy attachment to any life jacket or clothing. The bright LED distress light activates automatically when submerged in water.

NEW 2011

- 3 x LR44 batteries included
- Lanyard: 170mm long
- Dimensions: 54(L) x 27 (D)mm

ST-3230

$6.95

SPRING SALE ON AUTO & OUTDOORS PRODUCTS

Listed below are discontinued items that we can no longer afford to hold stock. Savings Off Original RRP no rainchecks, may not be available at all stores - call your local store to check stock. Valid from 24/09 - 23/10/2011.

Product Description	Cat No	Original RRP	Special Price	Save $$$
100WRMS Full Range Car Amplifier	AA-0456	$399.00	$299.00	$100.00
Car Amplifier Resp 5Ch Full Range	AA-0458	$449.00	$349.00	$40.00
Car Battery Charger/Booster Solar	MB-3503	$37.95	$16.95	$21.00
Car Noise Filter 40Amp	AA-3081	$29.95	$19.95	$10.00
Car Stereo Line Isolation Transformer	AA-3085	$19.75	$10.75	$9.00
Car Speakers 5" VIPA 2 Way 60WRMS	CS-2393	$99.00	$59.00	$40.00
Car Speakers 6 x 9" VIPA 4 Way 150WRMS	CS-2397	$189.00	$129.00	$60.00
Car Speakers 6.5" VIPA 2 Way 80WRMS	CS-2395	$129.00	$89.00	$40.00
Car Speakers 6.5" VIPA Splits 80WRMS	CS-2399	$199.00	$159.00	$40.00
Fuse Maxi Gold Pack of 2 Gold	SF-1952	$8.95	$7.95	$1.00
In Car Mobile Phone Charger	MB-3546	$19.95	$8.95	$11.00
In Car Retractable Phone Charger	MB-3579	$19.95	$13.95	$6.00

Product Description	Cat No	Original RRP	Special Price	Save $$$
Light LED Recessed Blue	ST-3888	$19.95	$8.95	$11.00
Microwave Sensor for Car Alarms	LA-9030	$34.95	$29.95	$5.00
Motorcycle Alarm	LA-9020	$59.95	$49.95	$10.00
Parking Assist System with Camera	QC-3726	$299.00	$139.00	$160.00
Power Window Closer 2 Door	LR-8851	$59.95	$19.95	$40.00
Sound Absorbing Tiles Economy 32mm	AX-3654	$12.95	$3.95	$9.00
Speaker Grille Clamp Kit - Pk.4	AX-3530	$1.95	$0.45	$1.50
Speaker Grille Clamp Kit / 'T' nuts	AX-3542	$4.70	$1.30	$3.40
Torch - CREE® Tactical LED 8D	ST-3398	$59.00	$17.00	$42.00
Torch - Dynamo 2LED Keyring Mini	ST-3348	$12.95	$2.95	$10.00
Torch - Dynamo Pocket Sized	ST-3331	$14.95	$11.95	$3.00
Torch - LED Keyring with Solar Charging	ST-3389	$9.95	$4.95	$5.00

Better, More Technical *All Savings are based on Original RRP Limited stock on sale items.* **To order call 1800 022 888**

BATHROOM GADGETS

Waterproof Bathroom Clocks with Suction

NEW 2013

Truly convenient and waterproof analogue clocks. The suction cup allows you to mount it on to any smooth surface like a tiled wall or mirror. Available in blue and pink.

- Requires 1 x AA battery
- Approx. 130(Dia)mm

Blue **AR-1757**
Pink **AR-1758**

$9.95 ea

Water Resistant FM Shower Radio

NEW 2013

Features spring-loaded hanging hook, push button tuning and volume, splash proof and timer alarm. It also has a dial light, which stays on for a few seconds to assist in station identification etc.

- Requires 3 x AA batteries (use **SB-2425** $3.95)
- Dimensions: 145(L) x 80(W) x 63(D)mm

GH-1873

$29.95

Deluxe Automatic Soap Dispenser

NEW 2013

No more touching soap bottles! The unit automatically dispenses a suitable amount of liquid soap (adjustable). Features LCD display with auto cleaning mode.

- LCD displays amount of soap left, dispense amount adjustment, & battery condition
- Magnetic, removable drip tray
- Requires 3 x AA batteries
- Measures: 195(H) x 85(W) x 160(D)mm

GH-1188

$29.95

MINI APACHE 2 CH IR HELICOPTER

This easy to fly mini 2-Ch Infrared Apache helicopter has robust moulded plastic construction to take the inevitable bumps and occasional crash. 20 minute charge gives about 10 minutes flying time. The chopper recharges directly from the remote unit.

- Remote requires 6 x AA batteries
- Suitable for ages 10+
- Dimensions: 160(L)mm approx

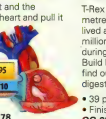
GT-3273 WAS $29.95

$24.95 SAVE $5

ANATOMY MODELS

Human Heart Anatomy Puzzle

A fantastic way to learn how the heart and the vascular system work. Assemble the heart and pull it apart again to see how the chambers and valves in the heart keep blood pumping around the body.



- 31 parts
- 95mm high
- Recommended for ages 8+

GG-2380 WAS $24.95

$14.95 SAVE $10

Also available:
1:1 Scale Human Heart Model **GG-2378** WAS $49.95 NOW $34.95 SAVE $15.00

MINI RECHARGEABLE USB KEYCHAIN SPEAKER

NEW 2013

Compatible with any device and features a 3.5 mm headphone socket such as iPods, MP3 players, PDAs, portable games and computers. Comes with a USB connection to recharge the built-in battery.

- USB & 3.5 - 3.5mm cable included
- Measures: 25(W) x 25(H) x 25(D)mm

XC-5178 WAS $19.95

$14.95 SAVE $5

35MM PHOTO FRAME FLASHLIGHT KEYRING

NEW 2013

Holds up to 100 photos which can be downloaded from a MAC or PC. Unit features an LED torch and comes with mini USB lead and stand.

- Battery rechargeable via USB
- Dimensions: 68(L) x 42(W) x 13(D)mm

Introductory DEAL!

XC-0211

$24.95

Buy 2 for $49 SAVE $9.90

DELUXE MINI WEATHER STATION

A compact weather station, altimeter, timer, alarm clock and ordinary clock. Has a nifty little handle that goes straight on to a carabiner. Ideal for canoeists, abseilers and other outdoor type activities.

- Includes 1 x CR2030 battery
- Measures: 70(L) x 45(W) x 15(D)mm (less handle)

XC-0358

NEW 2013

$29.95

Tyrannosaurus Rex Anatomy Model

T-Rex was about 15 metres long and lived around 65 - 85 million years ago during the Late Cretaceous period. Build him piece by piece and find out how he managed to digest 230kg of meat per bite.

- 39 pieces
- Finished model: 570(L) x 23(H)mm

GG-2394 WAS $89.95

$74.95 SAVE $15

MINI SOLAR RACE CAR KITS

NEW 2013

Fun and functional mini solar race car kit with built-in electric motor. No glue required - simply snap all the pieces together. The sun or a 50W halogen globe powers both models.

- Size: 60(L)mm
- Suitable for ages 10+

Red **GT-3755**
Green **GT-3756**

$12.95 ea

ELECTRONIC BUGS

Automated Electronic Bugs

NEW 2013

Keep your kids entertained for hours with these small robotic creatures! They will run and scurry around on an even floor, table and flat surface and have the ability to change direction if they hit an obstruction.

- Assorted Colours
- Suitable for ages 5+
- Dimensions: 45(L) x 17(W)mm

YG-2891

$4.95

Electronic Bug Maze

NEW 2013

A fantastic electronic bug habitat set. Comes complete with all the pieces required to build a beautiful home for the two electronic bugs supplied. Pieces are easily connected in place. Incorporate two mazes together to build and even bigger area for the bugs to explore in. More bugs, more fun it is!

- Additional Electronic Bugs sold separately YG-2891

YG-2893

$29.95

SPRING SALE ON GENERAL CONSUMER PRODUCTS

Listed below are discontinued items that we can no longer afford to hold stock. Savings Off Original RRP, no rainchecks, may not be available at all stores - call your local store to check stock. Valid from 24/09 - 23/10/2011.

Product Description	Cat No	Original RRP	Special Price	Save $$$
2Robot Chess Board	GT-3516	$299.00	$199.00	$100.00
Anatomy Model Animal Cell	GG-2396	$29.95	$24.95	$5.00
Anatomy Model Frog 3D	GG-2390	$34.95	$24.95	$10.00
Anatomy Model Human Brain 3D	GG-2383	$24.95	$19.95	$5.00
Anatomy Model Human Ear 3D	GG-2382	$24.95	$19.95	$5.00
Anatomy Model Human Eye 3D	GG-2381	$24.95	$19.95	$5.00
Anatomy Model Human Skeleton 3D	GG-2385	$24.95	$19.95	$5.00
Battery Operated Water Pump	GH-1118	$14.95	$9.95	$5.00
BBQ Tool Set Pink	GG-2307	$24.95	$9.95	$15.00
Book Light Slimline LED	ST-3980	$12.95	$5.95	$7.00
Calculator Solar with Pink Rhinestones	GH-1892	$19.95	$8.95	$11.00
Digital Mobile Microscope Handheld 60xZoom	QC-3248	$59.95	$35.95	$24.00
Digital Mobile Microscope 90xZoom	QC-3246	$249.00	$89.00	$160.00
Digital Photo & Video Camera for Kids	QC-3188	$49.95	$29.95	$20.00
Digital Photo Viewer with Alarm Clock	QM-3778	$29.95	$14.95	$26.00
Digital Voice Recorder 2GB 800 Hour	XC-0382	$129.00	$69.00	$60.00
Digital Voice Recorder 64MB 26 Hour	XC-0380	$69.95	$34.95	$35.00
Keyboard with Pink Rhinestones USB	GH-1899	$59.95	$24.95	$35.00
Kitchen Scales with Clock & Temp/Humidity	XC-0161	$44.95	$29.95	$15.00
Monitor LCD 7" USB Plug and Play	QM-3748	$269.00	$199.00	$70.00
RC Audi R8 27MHz	GT-3696	$59.95	$39.95	$20.00
RC Cars Wall Climbing Battle Pair	GT-3285	$79.95	$24.95	$55.00
RC Car Remote 2.4GHz 3-Channel	DC-1500	$149.00	$119.00	$30.00
RC Fail-Safe Device	DC-1504	$24.95	$19.95	$5.00
RC Ferrari 1:10 Scale F1 2008	GT-3201	$89.95	$69.95	$20.00
RC Helicopter - Mini 3 Channel IR Rechargeable	GT-3272	$39.95	$29.95	$10.00
RC Helicopter - Mini 4 Channel IR Rechargeable	GT-3279	$79.95	$59.95	$20.00
Solar Rechargeable Keyhole Light	GH-1822	$9.95	$7.95	$2.00
Time Capsule Project Kit	KJ-8910	$34.95	$8.95	$26.00
VB Alarm Clock	AR-1769	$29.95	$14.95	$15.00

Tools & Test

Both meters include test leads

DIGITAL MULTIMETERS

Cat III 4000 Count Autoranging DMM

An accurate and easy to use autoranging DMM. Select the parameter required and the meter chooses the appropriate display range. Features temperature, capacitance, data hold and auto power off plus a backlit display for measuring in dark places.

NEW 2011

- Display: 4000 count
- Dimensions: 150(H) x 70(W) x 50(D)mm

QM-1327 $34.95

Cat III 2000 Count Inductance / Capacitance DMM

A feature packed DMM with wide range of inductance (up to 20H) and capacitance (up to 200uF) measurement measured via the standard leads. Ideal for audio enthusiasts designing their own crossovers. Features large LCD, inductance, capacitance, data hold, auto power-off, and temperature measurement.

NEW 2011

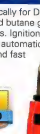
$49.95

- Display: 2000 count
- Hfe transistor test, diode test
- Dimensions: 195(H) x 92(W) x 55(H)mm

QM-1548

PORTASOL 50 GAS SOLDERING IRON

The Portasol 50 is designed specifically for DIY enthusiasts. Powered with standard butane gas, it has a run time of around 30 minutes. Ignition is via the flint igniter in the cap. Features automatic shut-off when the end cap is replaced and fast refill time. 1mm tip supplied.



- Operating time: 30 min
- Refill time: 10 sec
- Dimensions: 196(L) x 26(W) x 19(D)mm

TS-1300 WAS $34.95 $24.95 SAVE $10

Tips to suit

1.0mm Chisel TS-1301
WAS $14.95 NOW $9.95 SAVE $5.00

2.4mm Chisel TS-1302
WAS $14.95 NOW $9.95 SAVE $5.00

4.8mm Chisel TS-1303
WAS $14.95 NOW $9.95 SAVE $5.00

IP66 INDUSTRIAL ABS ENCLOSURES

Gasket seals, stainless steel hardware and IP66 rated for use in industrial, marine and other harsh environments. The closures have a locking catch that engages to positively hold the lid closed until disengaged. Each enclosure includes a 1.8mm galvanised chassis for mounting DIN rail, switchgear, relays or circuit breakers. A size for any application.

Small Opaque cover
- Dimensions: 125(L) x 125(W) x 75(D)mm

HB-6400
WAS $16.95 NOW $9.95 SAVE $7.00

FROM $9.95

Medium Opaque cover
- Dimensions: 175(L) x 125(W) x 75(D)mm

HB-6402
WAS $29.95 NOW $19.95 SAVE $10.00

Small Transparent cover
- Dimensions: 125(L) x 75(W) x 75(D)mm

HB-6410
WAS $16.95 NOW $12.95 SAVE $6.00

6 PIECE STAINLESS STEEL FOLDOUT BICYCLE TOOLSET

NEW 2011

A compact stainless steel bike tool set measuring at a handy 70mm. Contains all the drivers needed for quick repairs and adjustments making it an essential tool for any cyclist.

- 3 - 4 - 5 - 6mm hex
- 5mm flat screwdriver
- Philips screwdriver
- Dimensions: 70(L) x 25(W)mm

TD-2176 $19.95

12VDC VOLTAGE POLARITY EASTY TESTER

A passive, quick and easy testing solution that performs five essential tests in the field: voltage, load, polarity, voltage drop and continuity. The load applied is selectable between 1A or 500mA to test wiring depending on location, device to be tested, and anticipated voltage drop. Ideal for CCTV and security installers, car audio, roadies, AV techs etc.

- Dimensions: 51(L) x 44(W) x 29(H)mm

QP-2215 WAS $24.95 $19.95 SAVE $5

NON-CONTACT VOLTAGE TESTER/IR THERMOMETER

A non-contact AC voltage detector and IR thermometer. It provides easy and safe testing of mains voltages and heating systems. Essential tool for tradesmen.

- Detects AC voltage up to 1000V with LED indicator
- Precise non-contact temperature measurement
- Automatic range selection resolution 0.1°C (0.1°F)
- Celsius or Fahrenheit
- -30 to 230°C
- Automatic power-off
- Dimensions: 155(L) x 24(Dia)mm

QP-2269 WAS $59.95 $39.95 SAVE $20

STAINLESS STEEL BIT SETS

18 Piece Stainless Steel Mixed Bit Set

NEW 2011

A collection of commonly used driver bits in a handy rubber edged case. Features a bit locking mechanism for stable driving. All stainless steel. Driver not included.

- Contains: Torx: T10, T15, T20, T25, T30, T40 Flat blade: 3.5, 5.5, 6.5 Philips head: 1, 2, 2, 2, 3 Hex: 4, 5, 6
- Case dimensions: 115(L) x 50(W) x 31(D)mm

TD-2111 $29.95

21 Piece Stainless Steel Micro Bit Set with Driver

NEW 2011

Contains a collection of stainless steel bits for all repairing jobs such as watch, mobile phones, sunglasses repairs and more. Housed in a neat rubber edged case to withstand small knocks and bumps. Driver included.

- Contains: Hex: 0.7, 0.9, 1.3, 1.5, 2 Torx: T5, T6, T7, T8, T9, T10, Philips: 000, 00, 0,1 Flat blade: 0.8,1.2,1.5, 2,2.5
- Case dimensions: 115(L) x 50(W) x 31(D)mm

TD-2110 $29.95

ISOPROPYL ALCOHOL CAN - 300G

One of the most useful service aids around. Use as head, surface and contact cleaning, stain removal in laundry etc. Medical grade disinfectant and ideal for cleaning a windscreen before putting new rego label on.

NEW 2011

- 300g

NA-1067 $9.95

NOTE: Can't be sent by airmail.

SPRING SALE ON TOOLS, TEST & IT PRODUCTS

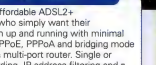
Listed below are discontinued items that we can no longer afford to hold stock. Savings Off Original RRP, no rainchecks, may not be available at all stores - call your local store to check stock. Valid from 24/09 - 23/10/2011.

Product Description	Cat No	Original RRP	Special Price	Save $$$
2.5/3.5" SATA HDD Dock with Card Reader	XC-4682	$69.95	$59.95	$10.00
4-Port Coloured Flexible USB Hub	XC-4878	$19.95	$8.95	$7.00
Adaptor Plug D9 - Plug PS2	PA-0944	$8.95	$0.75	$8.20
All-In-One Memory Card Reader	XC-4856	$19.95	$11.95	$11.00
Bottle Opener with LED Torch and Knife	TH-1901	$11.95	$2.95	$9.00
Display Panel 2 x Digit LCD - BARGAIN	QP-5514	$4.95	$1.50	$3.45
Display Panel LCD 2x16 Character Compact	QP-5519	$29.95	$7.95	$22.00
DMM - 16 Channel Cable Identifier	QM-1329	$79.95	$53.95	$26.00
DMM - Auto Ranging Cat IV 600V IP67 Rated	QM-1326	$69.95	$59.95	$10.00
DMM - Cap/Freq/Hold 3.5Digit	QM-1535	$29.95	$19.95	$10.00
DMM - Digital Capacitance	QM-1572	$59.95	$39.95	$20.00
DMM - Dwell Tacho	QM-1440	$39.95	$34.95	$5.00
DMM - Frequency/Temperature/Cap/Trans	QM-1320	$24.95	$17.95	$7.00
DMM - Protek 608 True RMS with PC Interface	QM-1292	$299.00	$229.00	$70.00
DMM - Cat4/Cat3 True RMS	QM-1623	$199.00	$110.00	$89.00
DMM - True RMS Autoranging	QM-1536	$79.95	$49.95	$30.00
Enclosure 2.5" IDE HD w/Security	XC-4668	$99.00	$40.00	$59.00
Epoxy Repair Putty 28g	NA-1520	$5.95	$1.95	$4.00
Flammable Gas Detector	QM-1980	$69.95	$34.95	$35.00
Goot Lead Free Solder	NS-3094	$24.95	$19.95	$5.00
HDMI Cable Tester	AA-0406	$149.00	$69.00	$80.00
IP68 Rated USB Optical Mouse	XM-5139	$39.95	$17.95	$22.00
IR Non-Contact Pocket Thermometer	QM-7219	$49.95	$24.95	$25.00
Lead - Computer IDE 3Socket ATA 133	PL-0974	$35.00	$6.00	$29.00
Lead - Computer IDE 3Socket Ribbon	PL-0946	$7.95	$6.95	$1.00
Lead - PS2 Plug to 2 Socket Adaptor	PL-0877	$12.95	$3.95	$9.00
Micro USB Digital Tuner	XC-4897	$89.95	$64.95	$25.00
Mobile Phone Tool Kit - 11 piece	TD-2024	$14.95	$8.95	$6.00

Better, More Technical *All Savings are based on Original RRP. Limited stock on sale items.* **To order call 1800 022 888**

SINGLE PORT ADSL2+ MODEM

An excellent and affordable ADSL2+ modem for those who simply want their internet connection up and running with minimal fuss. It supports PPPoE, PPPoA and bridging mode for connection to a multi-port router. Single or ranged port forwarding, IP address filtering and a built-in firewall gives this unit the basics to get you online securely. See website for full list of features and specifications.



- 1 x RJ45 port
- Filter/splitter included
- 1 x USB port for USB access to the modem/internet

YN-8316

NEW 2011

MORE INFO AVAILABLE ONLINE

$39.95

INDUSTRIAL IP68 USB KEYBOARD

Simply wipe it clean with a soapy sponge when it gets dirty. Perfect for factory floors, food & beverage counters, laboratories and industrial use. Comes with a custom-fit silicone sleeve for added protection.

- Anti-bacterial rubber construction
- Full-sized QWERTY layout
- USB connectivity
- Windows compatible
- Dim: 440(L) x 138(W) x 12(H)mm

XC-5141 WAS $99.00

$49.00 SAVE $50

EXPRESS CARDS

ExpressCard to eSATA Converter with Power Over eSATA

An eSATA port on your laptop will allow you to write and read data from external hard drives at a much faster speed than USB2.0. This card will eliminate the need for an external power source for the drive instead, the data and power will come through the single eSATA cable.

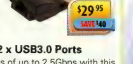
- Windows compatible
- Dimensions: 34(W) x 12(H) x 121(D)mm

XC-4142 WAS $49.00

$19.00 SAVE $30

ExpressCard Gigabit Ethernet

Slot this ExpressCard into the 34mm socket on your laptop for gigabit network capabilities. The device will auto-negotiate to 10/100/1000Mbps networks.



- Windows compatible
- Dimensions: 34(W) x 16(H) x 117(D)mm

XC-4146 WAS $69.95

$29.95 SAVE $40

ExpressCard with 2 x USB3.0 Ports

Achieve transfer speeds of up to 2.5Gbps with this ExpressCard to 2 x USB 3.0 port adaptor for your laptop. Though unable to reach the maximum theoretical speed of USB 3.0 due to ExpressCard bandwidth limitations it is still more than triple the speed of USB2.0 (480Mbps).

- Compatible with XP, Vista and 7 (32-bit and 64-bit)
- Compliant with ExpressCard standard release 0.95
- ExpressCard/43 form factor
- Backward compatible with USB 2.0/1.1
- Dimensions: 95(L) x 68(H) x 14(D)mm

XC-4141 WAS $59.95

$39.95 SAVE $20

ARDUINO DEVELOPMENT KITS

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs (includes Jaycar stepper motors). Arduino projects can be stand-alone, or they can be communicated with software running on your computer. These Arduino development kits are 100% Arduino compatible.

433MHz Receiver Shield for Arduino

Add a receiver module to your Arduino project to receive signals from 433MHz wireless devices including weather stations, home automation remote controls, power consumption meters, car alarms, etc.

- Supplied with 433MHz receiver module.

XC-4220

NEW

$29.95

EtherTen (100% Arduino Compatible with Onboard Ethernet)

100% Arduino compatible board that can talk to the world. Do Twitter updates automatically, serve web pages, connect to web services, display sensor data online, and control devices using a web browser. Any project you would previously have built with an Arduino and an Ethernet shield stacked together, you can now do all in a single, integrated board.

See website for more details.

- Gold-plated PCB
- Top and bottom parts overlay
- Top-spec ATmega 328P MCU
- Rounded corners

XC-4216

MORE INFO AVAILABLE ONLINE

$69.95

Eleven (100% Arduino Uno Compatible)

General-purpose programmable board containing the ATmega328 microprocessor with a boot loader program. It has the standard I/O and is 100% compatible with the original Arduino concept. See website for more information.

- USB cable and guide sheet included

XC-4210

$39.95

ProtoShield Basic for Arduino

Fits directly onto an Arduino compatible board such as the Eleven. The PCB surface is gold-plated for durability and it has connection markings on both top and bottom for easy identification.

- Size: 59(L) x 53(W)mm

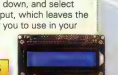
XC-4214

MORE INFO AVAILABLE ONLINE

$4.45

16 x 2 LCD Shield for Arduino

Add a 16 character by 2 line LCD display to your Arduino project. It plugs straight into the Arduino board or other project shields and features 5 buttons and a controllable blue backlight. The buttons provide left, right, up, down, and select while using just one analog input, which leaves the other analogue inputs free for you to use in your projects. The display can be panel mounted if required.



- LCD backlight
- Gold-plated PCB

XC-4218

NEW

$29.95

Terminal Shield for Arduino

Breaks out all the Arduino headers to handy screw terminals, making it easy to connect external wires without using a soldering iron. Ideal for quick experiments or for robust connections!

- Gold-plated surface

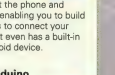
XC-4224

NEW

$16.95

USBDroid with onboard Android/USB Host

Just like an Eleven but with a microSD slot and extra USB port designed to connect with Android devices like the HTC Desire and Nexus mobile phones or the Xoom tablet. It's specially designed to be compatible with the Android Open Accessory Development Kit so you can write software to get the phone and USBDroid to talk each other, enabling you to build your own Android peripherals to connect your phone to whatever you like. It even has a built-in charger to recharge the Android device.



XC-4222

NEW

$69.95

Getting Started with Arduino

This book explains what Arduino is and how it works, and what you can do with it. It also includes a project to build, complete with how to write the code to make it work.

- Softcover 118 pages. 218 x 140mm

BM-7130

$23.95

Also available:
Practical Arduino **BM-7132** $57.95

WIRELESS USB TRACKBALL REMOTE CONTROL FOR PC

The trackball works as a mouse or any other pointer device and you can type numbers or text in the same way you do with a mobile phone. It also has quick-launch keys, plus controls for multimedia use - play, pause, record etc. You can also program macros or single commands into any key.

- 2.4 GHz wireless transmission on 10m range
- 19mm optical trackball & mouse keys
- USB dongle receiver
- Requires 2 x AA batteries
- Dimensions: 180(L) x 50(W) x 30(H)mm

XC-4940 WAS $89.00

$59.00 SAVE $30

CAT6 PATCH CABLES

Range of Cat6 cables. Available in lengths from 500mm to 10m.

- Patch leads meet TIA/EIA 568B2.1
- 50 microns of gold plate on each connector

500mm	YN-8280	$5.95
1m	YN-8282	$6.95
2m	YN-8284	$8.95
3m	YN-8286	$10.95
5m	YN-8288	$14.95
10m	YN-8290	$24.95

NEW 2011

FROM $5.95

Limited stock on sale items.
All Savings are based on Original RRP

Jaycar Electronics
Better, More Technical

Spring Sale

UP TO 80% OF ALL LISTED ITEMS!

BIG SPRING SALE

Listed below are a number of discontinued items that we can no longer afford to hold stock. You can get most of these items from your local store but we can not guarantee this. Please ring your local store to check stock. At these prices we won't be able to ship from store to store. ITEMS WILL SELL FAST AND STOCK IS LIMITED. ACT NOW TO AVOID DISSAPOINTMENT. Sorry no rainchecks!

Product Description	Cat No	Original RRP	Special Price	Save $$$
Hardcore Products				
Enclosure Polycarb Sealed Clear	HB-6246	$17.95	$12.95	$5.00
Fixed Inline Attenuator	LT-3051	$9.95	$5.95	$4.00
Flexible Conduit 2m	HP-1320	$3.95	$2.95	$1.00
Gearbox / Motor Suit High Power Pinion Drive	YG-2747	$29.95	$20.00	$9.95
Gearbox / Motor Set Six-Speed	YG-2744	$32.95	$29.95	$3.00
Globe - Halogen 12V 50W 51mm 3BD Lens Green	SL-2742	$7.95	$4.45	$3.50
Globe - Halogen 12V 50W 51mm 3BD Lens Red	SL-2741	$7.95	$2.25	$5.70
Globe - Halogen MR11 12V 20W 35mm	SL-2733	$7.45	$2.75	$4.70
Globe - Halogen MR16 12V 20W 51mm	SL-2723	$7.45	$2.75	$4.70
Globe - Halogen MR16 12V 50W 51mm	SL-2731	$7.45	$2.75	$4.70
Globe - Halogen MR16 24V 50W 51mm	SL-2732	$8.95	$2.75	$6.70
IC Command Control Decoder ZN4069CE	ZK-8827	$28.00	$7.00	$21.00
IC Module 50W Audio Power Amplifier	ZL-3762	$19.95	$5.95	$14.00
IC Module 70W Audio Power Amplifier	ZL-3764	$23.95	$7.95	$16.00
In-Sure 2 Port Push In Connectors	HM-3260	$4.95	$2.95	$2.00
In-Sure 3 Port Push In Connectors	HM-3262	$5.50	$3.50	$2.00
In-Sure 4 Port Push In Connectors	HM-3264	$4.50	$2.50	$2.00
LED - Flexible Strip with 3x5MD 12V Blue	ZD-0474	$7.95	$2.95	$5.00
LED - Flexible Strip with 3x5MD 12V White	ZD-0470	$7.95	$6.95	$1.00
LED - Lamp GU10 x 3 CREE LED Downlight White	ZD-0364	$49.95	$29.95	$20.00
LED - Lamp MR16 2.1W Louvered White	ZD-0340	$19.95	$9.10	$10.00
LED - Lamp MR16 12V 20xRed	ZD-0323	$24.95	$4.95	$20.00
LED - Lamp MR16 12V 20xYellow	ZD-0324	$24.95	$3.95	$21.00
LED - Lamp MR16 Downlight 300Lumen White	ZD-0356	$59.95	$39.95	$20.00
LED - Light Bar Module 12V White	ZD-0450	$9.95	$4.95	$5.00
LED - SMD Pink P6B	ZD-2022	$24.95	$4.95	$20.00
LED - Star Module 1W Blue	ZD-0506	$12.95	$4.95	$8.00
LED - Star Module 1W Luxeon Amber	ZD-0401	$12.95	$4.95	$5.00
LED - Star Module 1W Luxeon Red	ZD-0400	$14.95	$9.95	$5.00
LED - Star Module 1W Luxeon Royal Blue	ZD-0405	$14.95	$9.95	$5.00
LED - Star Module 1W Luxeon White	ZD-0500	$12.95	$3.95	$9.00
LED - Star Module 1W Side Emitting White	ZD-0407	$17.95	$5.95	$12.00
LED - Star Module 1W Warm White	ZD-0510	$12.95	$3.95	$9.00
LED - Star Module 1W White	ZD-0508	$12.95	$9.95	$3.00
LED - Star Module 3W Blue	ZD-0526	$39.95	$17.95	$12.00
LED - Star Module 3W Luxeon Amber	ZD-0434	$29.95	$11.95	$18.00
LED - Star Module 3W Luxeon Red	ZD-0438	$29.95	$11.95	$18.00
LED - Star Module 3W Luxeon Green	ZD-0436	$29.95	$11.95	$18.00
LED - Star Module 3W Luxeon Red	ZD-0432	$29.95	$17.95	$12.00
LED - Star Module 3W Red	ZD-0520	$19.95	$7.95	$12.00
LED - Star Module 3W Warm White	ZD-0530	$19.95	$7.95	$12.00
LED - Star Module 3W RGB* XM Warm White	ZD-0420	$19.95	$12.95	$7.00
LED - Star Module Edixeon 3W Warm White	ZD-0534	$24.95	$19.95	$5.00
LED - Star Module Edixeon 3W White	ZD-0532	$24.95	$12.95	$12.00
LED 1W Blue	ZD-0414	$12.95	$4.95	$8.00
LED 1W Red	ZD-0410	$10.95	$3.45	$7.50
LED 5mm 2000MCD Pink	ZD-0199	$15.95	$4.95	$11.00
LED Globe 12xWhite Bayonnet 12V	ZD-0306	$26.95	$12.95	$14.00
Metal Diode Varistor (MOV) 130VAC 57J 4500A	PR-3408B	$1.35	$0.15	$1.20
Plug F59 Compression Crimp Waterproof	PP-0670	$1.85	$1.65	$0.20
Plug F59 Screw Type	PP-0671	$2.15	$1.75	$0.40
Servo Futaba Star Horn Pk4	YG-2759	$4.95	$3.95	$1.00
Servo Horns to Suit Heavy Duty Servo Pk2	YM-2760	$6.95	$5.95	$1.00
Servo Horns to Suit Standard / Mini Servos Pk6	YM-2768	$6.95	$5.95	$1.00
Socket IC 24Pin Machined	PI-6464	$2.80	$0.50	$2.30
Socket Mains Single 240V GPO with Extra Switch	PS-0404	$6.95	$4.45	$2.50
Socket Memcard 4in1	PS-0032	$18.95	$17.95	$1.00
Sprocket Set & Ladder Chain	YG-2787	$19.95	$17.95	$2.00
Switch - Keypad SPDT MOM Black/Green LED	SP-0776	$2.95	$1.15	$1.80
Switch - Keypad SPDT MOM Black/Red LED	SP-0775	$2.95	$1.15	$1.80
Switch - Keypad SPDT MOM Black/Yellow LED	SP-0778	$2.95	$1.15	$1.80
Switch - Pushbutton Illuminated MOM 12V	SP-0750	$19.95	$7.95	$12.00
Switch - Pushbutton Illuminated MOM 12V SPDT	SP-0753	$19.95	$7.95	$12.00
Switch - Pushbutton Illuminated SQR 12V	SP-0742	$22.95	$13.95	$9.00
Switch Light Sensitive 240VAC 10A	AA-0326	$24.95	$22.95	$2.00
Toroidal 3.2vA	MT-2030	$21.95	$8.95	$13.00
Toroidal 7vA	MT-2036	$24.95	$8.95	$16.00
Wall Plate with Double HDMI Socket White	PS-0286	$29.95	$8.95	$21.00

Product Description	Cat No	Original RRP	Special Price	Save $$$
Power Products				
Adaptor Mains 12V 8A	MP-3470	$44.95	$39.95	$5.00
Battery - iPod® 1G/2G Li-Poly	SB-2570	$29.95	$19.95	$10.00
Battery - iPod® Mini Li-Ion	SB-2576	$23.95	$19.95	$4.00
Battery - iPod® Nano 1G	SB-2578	$23.95	$19.95	$4.00
Battery - iPod® Shuffle 1G	SB-2578	$23.95	$19.95	$17.00
Battery Bank with Alligator Clips and Switch	MP-3071	$9.95	$3.95	$6.00
Battery Lithium Panasonic BR-C 3V	SB-2414	$15.00	$6.00	$9.00
Battery Nicad 1.2v 4/5Sub C	SB-1618	$9.95	$5.50	$4.45
Battery NiMH 3.6V	SB-1606	$14.95	$9.95	$5.00
Battery Power Selector 70Amp	MB-3672	$99.95	$31.95	$68.00
Battery Stick Pack RC 7.2v 700mAh NI-MH	SB-2308	$14.95	$12.95	$2.00
Charger - Ni-Cd/Ni-MH 12V	MB-3630	$59.95	$39.95	$24.00
Charger Car for iPhone®/iPod®	MB-3654	$19.95	$12.95	$7.00
Converter 12/24 - 9V USB	MP-3656	$9.95	$9.95	$0.00
Converter 12V to 5V for GPS/PDA	MP-3046	$29.95	$17.95	$12.00
Converter 12V to 5V with USB	MP-3047	$17.95	$8.95	$9.00
Mains Power Monitor	MS-6155	$199.00	$139.00	$60.00
Additional Sensor for MS-6155. Power Monitor	MS-6156	$19.95	$17.95	$2.00
Power Supply Switchmode 5VDC 2A	MP-3230	$23.95	$20.95	$3.00
Power Supply Switchmode 6VDC 1.66A	MP-3232	$23.95	$5.95	$18.00
Power Supply/I/F Switchmode Halogen Lamp 105W	MP-3061	$17.95	$15.95	$2.00
Power Supply/I/F Switchmode Halogen Lamp 150W	MP-3053	$24.95	$21.95	$3.00
RF Remote Controlled Receiver 240V	MS-6138	$29.95	$9.95	$20.00
Lighting Products				
LED Door Light Solar with PIR	SL-2750	$39.95	$24.95	$15.00
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SERVICEMAN'S LOG

There's lots of ways to kill a laptop . . .

Dave Thompson*

Unlike desktop PCs, laptops suffer from all sorts of accidental damage, sometimes fixable and sometimes not. Where possible though, we do like to repair them and keep them going.

Items Covered This Month

- Fixing a laptop power socket
- The Breville stab mixer
- A shonky antenna modification

*Dave Thompson, runs PC Anytime in Christchurch, NZ.

It's a fact of life that lower-end laptops and desktops are now often treated as consumable items; something to be chucked away if they fail as repairs are deemed too expensive.

However, I don't consider this to be the best approach. Apart from the adverse ecological impact, it also wastes tonnes of valuable (and sometimes dwindling) resources. Our rubbish bins are too often fed computers and components that could easily be salvaged, recycled and re-used.

In light of this and other excesses in the industry, we try to offer as many options as we can, especially for laptop repair. Provided the economics stack up, the aim is to keep a machine going for at least its expected average life.

When they bring in a faulty computer, many clients ask whether they should "just buy a new one" and throw the old one away. Less scrupulous retailers would probably jump at the chance for an easy sale but we like to check if the machine can be economically repaired first. Of course, if the machine is badly damaged or the repair is obviously not economically viable, we quickly advise the client to discard it. We may be green-aware but we are sensible about it.

Laptops are a special case in point, as they are so prone to accidental damage. We often see machines that have been dropped, sat-on, had coffee spilled over them or damaged in 101 other ways.

A classic recent example was a 14-month old laptop with a broken power socket. Laptop power sockets come in all shapes and sizes, some proprietary and some stock-standard, yet the majority share the same inherent fault – physical weakness. When a power supply is plugged in, enormous stresses can sometimes be placed on the socket. A common scenario is where a user forgets that the supply is plugged in and picks the machine up and waks off, only to be jerked to a stop as the power cable reaches its limit.

In such cases, it is just luck if the socket doesn't break under the strain. However, even if it doesn't break, it can be deformed to such an extent that the plug no longer makes decent contact, so the result is almost the same. In either case, a replacement is required.

Manufacturers go down either of two roads when attaching power sockets to motherboards. The first is where the socket is soldered directly onto the board while the other is where the socket is self-contained in a small moulded enclosure (often part of the case) and connected to the motherboard via a small loom and plug.

Both approaches have their advantages and disadvantages when it comes to repairs. The stand-alone version is obviously the easiest to replace, provided a spare part is available. If it isn't, then there are problems, especially if the socket is an oddball one.

The same goes for the hard-soldered socket. In addition, these can be quite difficult to remove from the motherboard without damaging anything. It's a big ask, considering the amount of heat usually required to melt large soldered joints through double-sided boards.

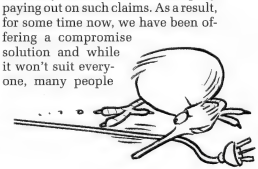
While a standard 40-watt soldering iron could be used, a specialist de-soldering tool such as a hot-air or suction-based station is worth its weight in gold for this type of work. The ability to replace items on motherboards in-house is a big plus for any company, saving everyone's time and increasing profitability as opposed to farming the work out to a third-party contractor.

But what can we do if we can't get a similar socket? Even with dozens of old laptop chassis and dead motherboards, the chances of finding a socket that fits perfectly in the old solder holes on the motherboard, or fits in the case moulding like the original, are very slim.

I have been lucky with many of the socket repairs I have carried out over the years, with spares being available either from the manufacturer or from one of the electronics suppliers around town. Lately, however, my luck appears to have run out and I've had several cases where I was unable to find a replacement that was similar enough to do the job.

For a machine in otherwise good shape, this is a real shame and not just because replacing laptop motherboards is typically expensive. In many cases, the boards are not even available in New Zealand as a spare part and buying and freighting one in from overseas is not economically viable either.

In the past, we used to advise claiming insurance for such faults, though this relied on the client having the necessary insurance and the company paying out on such claims. As a result, for some time now, we have been offering a compromise solution and while it won't suit everyone, many people



The life of LAZARUS the LAPTOP
HELP ME...
OWS!
OWS!
OWS!
OWS!
NOOOO!
EMERGENCY
AGAIN WITH THE DEFIBRILLATOR?
zzz

speed control circuit wasn't working properly.

It was then that I decided to check the diodes that I had removed from the unit. And that was it – three of them were shorted in both directions! No wonder the unit blew fuses!

The trick then was to fit more rugged diodes and I settled on 1N5408s. These are quite a bit larger than the RL257s and the pigtails are much larger – requiring drilling out the holes in the board. This in turn lifted some of the copper tracks and I had to wire in some links to replace the missing copper.

Eventually, I managed to mount all the new diodes in position and fit the board back into the selector switch housing. It was a very tight fit but it all worked OK. All I had to do then was wire in a slow-blow fuse and push it all back together.

Getting the pushbuttons back into the slots above the contacts was very difficult, as the whole assembly was put together with cost-saving in mind. The selector consisted of a strip of metal bent up at each end and fixed in the middle at the point of the AC input. The buttons then push the strip down at one end or the other to make contact with the "Hi" or "Low" terminals. Between each button and the strip is a spigot which is located by the plastic housing of the selector switch

Unfortunately, these spigots were relatively free to wander about and getting them and the pushbuttons to line up and stay in place was a very fiddly job. However, I finally got it all back together and what's more, it all worked perfectly.

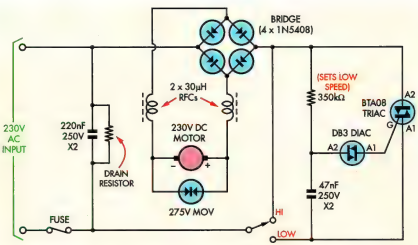


Fig.1: the motor control circuit in the Breville stab mixer uses a diode bridge circuit to feed the motor through two 30µH inductors. The Triac control circuit is switched in to give low-speed operation.

Of course, a new stab mixer can be purchased for about $60 so my time on the job would never have justified a commercial repair. However, it did add to my "experience"!

A shonky antenna modification

My next story comes from a fellow Kiwi, G. M. of Pukekohe, NZ. He recently had to deal with a mess left by a two-legged rat . . .

It was a Monday morning and I had arranged to call on a lady who lives in a pensioner flat not far from my workshop. Apparently, she had moved her TV from her bedroom to the lounge and now she couldn't get a picture, only snow.

When she first rang, I talked her through the connections from the wall socket to the VCR and on to the TV. It sounded as though she had done everything right but it simply wouldn't work. She then told me that she had recently moved into the flat and hadn't used that particular antenna outlet before – only the one in the bedroom which worked fine.

Now TV antenna systems in pensioner flats are not usually tampered with, so my initial thoughts were that the outlet must have worked for the previous tenant. It just had to be something simple like a connection

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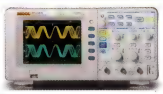

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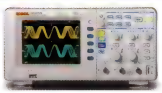

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SO IT WAS RATS ~ OF THE TWO LEGGED VARIETY

error on her part, or maybe one of those cheap, disgusting RF leads had gone open circuit. The braid on some of those cheap leads is so thin that it easily breaks if the lead is tugged too often.

Convinced that this would be an easy job to ease me into my working week, I duly knocked on her door and confirmed that she had everything connected properly. I then wiggled the antenna leads but not a flicker so I bypassed the VCR and connected the TV directly to the wall socket. That didn't work either so I tried substituting a new lead that I'd brought with me but still nothing.

Next, I tested the outlet using a small portable TV that I'd had the foresight to throw in at the last minute. There was still only snow so I removed the wall plate and confirmed that all was OK behind there. I then took the portable into the bedroom and plugged it into the outlet and it produced a beautiful picture on all channels.

That meant that we either had a faulty splitter, a faulty connection at the splitter or an open circuit in the cable running to the lounge room.

It would not be long before the ceiling space would be unbearably hot so I bit the bullet and fetched the ladder from the van, located the manhole and silently prayed that the splitter would be nice and handy. It was and a quick visual inspection showed that all the connections were fine. I swapped the bedroom and lounge-room connections anyway but nothing changed – the lounge room outlet was still faulty.

So the cable from the splitter to the lounge had to be faulty. A rat maybe? A check with my multimeter confirmed an open circuit.

I asked the lady if I could borrow a broom so I could use the handle as a "cobweb wand" to wave before me as I followed the cable to check its integrity. Murphy was determined to spoil the start to my week, as the manhole was at the exact opposite end of the flat to the lounge outlet. With my head light switched on, I lifted the cable from the dusty ceiling insulation as I worked my way along, "sweeping" cobwebs as I went.

Eventually, just before I reached the lounge end, I realised that the cable had more slack than it should have. I puzzled at the thought of a rodent chewing clean through it but you've got to expect the unexpected in this business.

I began to draw the cable toward me, hoping that the "break" was not halfway down the wall. And then, as the cable end came towards me, the light picked up something glinting on the loose end – it had a threaded F-plug attached. But why?

This particular antenna system would have been done long before F-plugs became trendy, so someone had been tampering after all!

To get to the bottom of the mystery, I now had to crawl the rest of the way on my belly due to the low pitch of the roof (the lounge outlet was on an outside wall). I groped around for the other end of the cable and eventually found it, much to my relief.

By now though, I was hot, sweaty, dirty and very angry. So much for my freshly-laundered overalls.

The "cut" lounge end of the cable which went down the wall to the outlet socket was also terminated with an F-plug. This in turn was connected to a joiner and then to another cable which disappeared off to my right. I could tell even in the gloom that this other cable was not original as it was heavier than the original cable. I disconnected this cable and made good the connection from the splitter to the lounge using the joiner.

After making my escape from the rapidly increasing heat of the ceiling space, I confirmed that all was now back to normal in the lounge and the reception was as near perfect as you could expect. I then went outside to breathe some fresh air and to confirm my suspicions. As I rounded the corner of the house, there it was, hidden from the road-side view – a satellite dish steadfastly focussed on the sky.

The previous tenants had obviously had the dish installed and had relied on a set-top box for their reception. However, the installer had been lazy and had probably lifted a concrete roof tile from the outside, just above the lounge socket, before conjuring up his dirty little trick of cutting into the original RG59 cable and then using the short length down the wall to complete the circuit.

Of course, it would have been very easy for him to have used the original

cable to pull up a draw wire from the lounge, then pull both cables back down and correctly terminate his cable to another wall-plate. But he didn't do that and so the lounge socket was left disconnected from the antenna.

So it was a rat after all, of the two-legged variety!

On a similar theme, I have seen some very shonky dish installations over the years. Often, the cable enters the house through a roughly-drilled hole straight through the outer and inner wall linings, with no wall plates installed. As a result, the weatherproofing of the external cladding is compromised and in one case I know of, a new lounge extension failed to pass its final inspection for this very reason.

Of course, it's human nature to want a job to flow easily and sometimes short-cuts are expedient. However, what this guy did was just downright sneaky and it ended up costing someone else money and inconvenience to correct his shortcut. The only thing I can say in his favour was that he'd had the decency to fit a plug to the loose end of the cable.

Unfortunately, customers cause more than their fair share of problems as well. For example, I wonder how many technicians have been caught out by the customer who has remade all the connections after relocating their TV and VCR (yes, some people still use them), then phones to say "my video's not working".

Of course, they somehow forget to mention that vital clue – that they have disconnected and reconnected everything.

You call to their home and peer into the back of the dark, dusty, cobweb-infested TV-cabinet to check the connections. At first glance, everything looks OK. The antenna lead from the wall disappears into the cabinet, the VCR has leads plugged into its RF IN and RF OUT sockets and the TV is also connected and works fine on broadcast signals.

When you ask them what channel they select to watch videos, they usually don't seem too sure. As a result, you set about retuning the TV to the VCR's output frequency on a blank channel, a really slow and tedious process with some older sets.

By playing a tape in the VCR, you will know when you've hit the correct channel (early VCRs had their own test-signal generator). However, having covered the spectrum without success, you conclude that maybe the VCR has dirty heads or is otherwise faulty. By this time, you've had enough of little Johnny romping around the room with the contents of your toolkit, so you keenly suggest taking the VCR back to the shop for a head clean.

And so you set about removing the VCR from the cabinet and that is when the penny drops. The customer has connected the antenna lead from the wall socket directly to the TV by routing it through the cabinet. The other antenna lead is indecently connected between the VCR's RF OUT socket and its RF IN socket! So there is no VCR signal connection to the TV at all.

And so you correct this rather silly mistake while making some sheepish excuse about how you missed that. You then suffer the indignity of having to retune the TV which had probably been correctly tuned all along.

Of course, there's no way you can charge for the time wasted in doing this, so you've just got to get on with it and look as happy as you can. And often, you can't even sell them an A/V lead to connect the VCR to the TV (instead of the antenna lead) because the only input on the TV is already connected to a set-top box.

It really is time that some customers upgraded to flat-screen TVs but not everyone can afford to do that. SC

You can do it with your PC . . .

By JIM ROWE

Measuring Audio Gear - without spending $$$$!

So you want to measure the performance an amplifier or other piece of audio gear. . . but you don't have thousands of dollars for the "right" test gear. No problem – all you need is a PC, a decent sound card (or a USB sound interface), plus an appropriate software package. Here's how it's done:

In the old days, checking the performance of audio equipment like amplifiers and preamps usually involved a fair bit of test gear: an audio generator, an audio millivoltmeter (or better still a distortion and noise meter), a scope to keep an eye on clipping and hum and some resistive 'dummy loads' to provide the audio equipment with its correct loading (standing in for things like speakers, with their complex impedances).

And even when you had all of this test gear on hand, the actual testing was a rather tedious and time-consuming operation.

Now, thanks to galloping digital technology, you do can do your own tests at much lower cost, using a recent-model PC with a decent full-duplex sound card (or a USB Recording/Playback interface) plus a low cost digital audio analyser software package.

Before we start telling you how it's done, we don't want to mislead you about the kind of measurement results you can expect.

Although the performance of the digital analyser software tends to be excellent in the digital domain (ie, inside the PC itself), the performance 'outside' in the analog domain will inevitably depend very much on the circuitry inside the PC's sound card or USB sound interface – in particular, on the ADCs in the audio input circuitry and on the DACs in the audio output circuitry.

The analyser software can automatically correct for things like sound card frequency response variations and gain or loss in both the input and output analog circuitry but it can't really compensate for high noise and/or distortion levels in this circuitry.

The same qualifications tend to apply in the case of crosstalk inside the sound card/interface – both inter-channel crosstalk between the right and left channels (within both the input ADCs and the output DACs) and also crosstalk directly between the ADCs and DACs.

With an 'el cheapo' sound card (such as that included in budget PCs or integrated with their motherboards) the results are likely to be fairly modest, while with a 'top of the range' sound card or interface they may well approach what could be achieved using a dedicated digital audio analyser system.

So to ensure the best possible results use the highest

If your PC sound card is not up to it, the SILICON CHIP USB Recording/ Replay Interface (published June 2011) would be an ideal partner for any PC-based audio equipment measurement setup.

performance sound card or interface that you can afford.

What you'll need

I'd recommend as a minimum using a Pentium 4 system (or better) running at 1.5GHz or better, with at least 512MB of RAM and a 80GB or larger hard drive. It should also be running either Windows XP, Vista or Windows 7 – which will again increase the demands for RAM and hard drive capacity.

Of course if the PC is already fitted with a top-quality sound card, so much the better. If it isn't, your best bet would be to buy or build a good USB sound interface, such as that described in the June 2011 issue of SILICON CHIP.

Software

You will also need a digital audio analyser software package, as mentioned earlier. There are a few of these around but the one that seems to have the best reputation is a package called 'TrueRTA', written by John L. Murphy, a former space systems software analyst for the US Air Force and an audio design engineer with over 20 years' experience.

Details of this software are summarised in the panel at right. After trying out the free Level 1 version myself for a few days, I decided to upgrade to Level 4 and the next day I was able to use this after entering the registration code. I'll be using the Level 4 version of TrueRTA to illustrate each aspect of doing audio testing with a PC throughout this article.

During the preparation of this article I've used TrueRTA Level 4 with a number of PC's as well as sound cards and USB interfaces. The PCs include a Compaq V2000 laptop running Windows XP, a Compaq D380mx desktop machine also running Windows XP and an Acer Aspire AX1800 machine running Windows 7 (64-bit version).

The SILICON CHIP USB Recording/Playback interface was used with the Compaq V2000 and the Acer AX1800, while I used a Creative Extigy USB interface with the Compaq

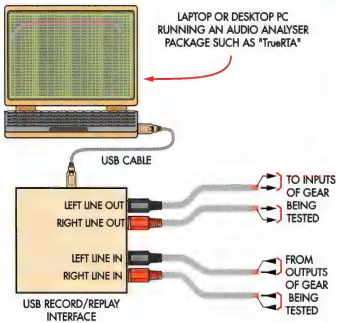


Fig.1: The basic setup for PC-based audio testing. The audio line outputs provide the test signals, while the line inputs connect to the meter, scope and analyser.

About TrueRTA™

Real Time Audio Spectrum Analyzer

TrueRTA is a software package available online from TrueAudio (USA). (www.trueaudio.com).

A limited capability version (Level 1) is available at no cost (ideal to try out and has no expiry date). The file ***TrueRTA_se.exe*** is less than 2MB in size and is a self extracting installer.

This can be upgraded to any of the three higher performance levels by buying the appropriate licence (no further download is needed). The Level 2 licence is $US39.95, Level 3 is $US69.96 while Level 4, the highest performance level, is $US99.95

TrueRTA runs on any PC with a Pentium 3 or better, running at 500MHz or faster and with at least 64MB of RAM plus a full-duplex sound card or USB audio interface, running Windows XP, Vista or Win7 (32-bit or 64-bit).

It is basically a suite of software-based audio test instruments, including:

1. A high resolution real-time analyser (spectrum analyser). The analyser resolution varies from one octave/band for the free Level 1 version, to 1/24th of an octave/band for the Level 4 version. The Level 4 version also provides selectable resolutions of 1/3, 1/6 and 1/12th of an octave. The analyser can display in either conventional bar mode or line mode, which is better for showing frequency response curves, etc. The maximum upper dBu limit is +20dBu, while the minimum lower dBu limit is -160dBu. These are the measurement limits of the software, of course; the performance of your sound card/interface will determine the actual measurement range. Other features of the analyser include selectable averaging, adjustable frequency range and the ability to store calibration curves for not only the PC's sound card/interface but also for a microphone so that it can be used for acoustic measurements on speakers etc. Once stored these curves can be automatically used to correct for system errors and improve measurement accuracy.

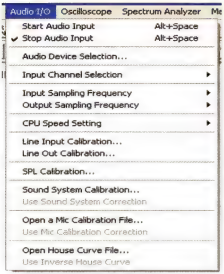
2. A low distortion digital audio signal generator, the output of which can be varied between 5Hz and 48kHz (when the sound card allows 96kHz sampling). In addition to the low distortion sinewave output the generator can be set to produce square waves (adjustable duty cycle), triangular, sawtooth and impulse waveforms, as well as pink noise and white noise. The higher level versions can also produce a digitally synthesised logarithmic sine sweep from 10Hz to 48kHz (or half the sampling rate), with a response flat within +/-0.05dB over the audible frequency range.

3. A dual trace DSO which covers the full audio spectrum. The amplitude range of each channel can be varied between 5V/division down to 1mV/division in the usual sequence of ranges, while the timebase ranges vary from 200ms/div to 50µs/div. Triggering is selectable in terms of the left or right channel and also adjustable in level.

4. A digital audio voltmeter which in the Level 4 version provides readout of the input level in millivolts RMS and dBu, together with the crest factor in either mV/mV or dB. Each of these four measurements can be selected individually, or all at the same time.

Each of the instruments can be started or stopped individually and when stopped the currently displayed measurement screen and all associated data can be saved to memory (up to 20 memories are available) and/or printed out (with or without user-added notes).

Fig.2: clicking on TrueRTA's Audio I/O menu button gives you this drop-down menu, which is used for most of the initial setup and calibration steps.



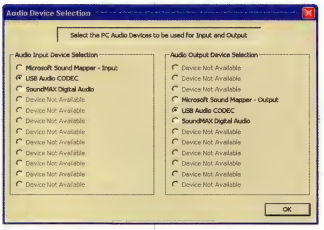


Fig.3. if you click on Audio Device Selection in the Audio I/O menu, this dialog box appears to let you select which audio input and output devices are to be used.

D380mx machine for comparison.

The basic set-up

Fig.1 shows the basic set-up for using a PC for audio equipment testing. The laptop or desktop PC is running an audio analyser package like TrueRTA, while the analog outputs and inputs of either the internal sound card or the USB sound interface are used as the system's interfaces to the gear being tested.

The line outputs are used to provide the test signals (from the software audio generator), while the line inputs are used to feed the output signals from the equipment you're testing back into the PC for analysis.

You can see from Fig.1 that in order to use the PC and its USB sound interface for audio testing, the operating system (ie, Windows) must be set up not only to use the USB interface as its 'default' sound card but also to configure it so that the 'recording' signals being fed in via the line inputs are NOT 'looped back' internally by the software to the line outputs (this is often done to allow 'record monitoring').

So as well as going into the Windows Control Panel and making sure that your USB Record/Playback interface is set as the default audio device for both recording and playback, it's also quite important to go into the Windows Playback Mixer dialog and make sure that the Line Inputs are not selected for playback – only the WAVE signals. This is usually the best way to ensure that the input ('recording') and output ('playback') functions are kept isolated from each other.

Another important step in your initial system set-up is to ensure that the recording and playback volume controls are each set to a known and easily repeatable level.

Usually with Windows XP and earlier operating systems this is 'maximum' – ie, with the software sliders set at their upper limit. However with Windows 7, you need to go into Control Panel/Sound/Recording and then select the Microphone function of your USB Audio Codec and open its Properties dialog.

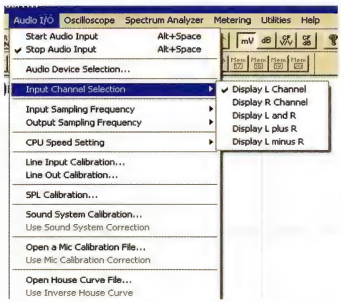


Fig.4: Then if you click on Input Channel Selection, a sub-menu lets you select which channel or channels are to be displayed.

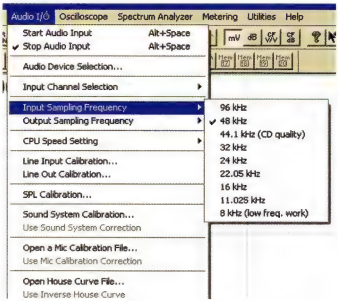


Fig.5: The Input Sampling Frequency sub-menu lets you to chose the highest input sampling frequency that your sound interface can handle.

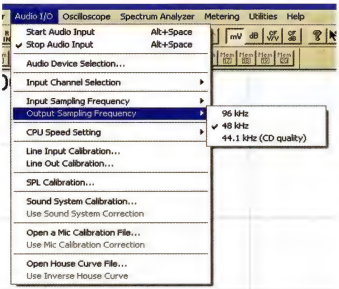


Fig.6: the Output Sampling Frequency flyout lets you match the output sampling frequency to the one you selected for the inputs in Fig.5.

Then you need to click on the Levels tab and move the Microphone volume slider almost fully to the left, until numeral '1' is being displayed in the box just to the right of the slider itself. This sets the 'recording' gain to unity, corresponding to a 'line level' input.

Initial checkout

You should now be ready to check that your audio testing software and hardware system is set up and functioning correctly. Do this by first starting up TrueRTA and then clicking on the Audio I/O menu button (in the top menu bar). This causes a drop-down menu to be displayed, as shown in Fig.2.

If you then click on Audio Device Selection, you'll see a

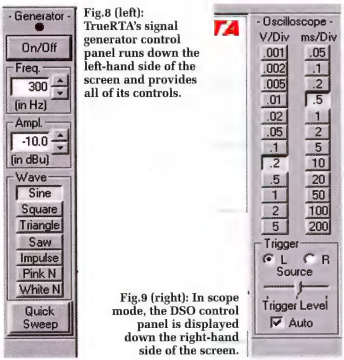


Fig.8 (left): TrueRTA's signal generator control panel runs down the left-hand side of the screen and provides all of its controls.

Fig.9 (right): In scope mode, the DSO control panel is displayed down the right-hand side of the screen.

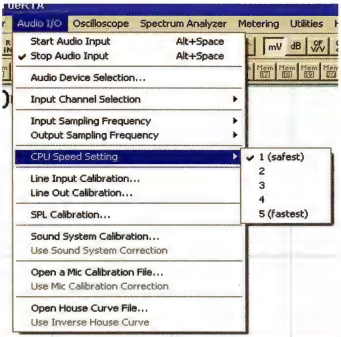


Fig.7: TrueRTA also lets you select the CPU Speed while it's running. Initially this is best left set to '1 (safest)'.

column of Input Device Selection choices on the left and a similar column of Output Device choices on the right (Fig.3). USB Audio CODEC should be selected. Then click on [OK] to close the dialog box.

Now click on the Audio I/O menu button again and this time click on Input Channel Selection. This will cause a sub-menu to appear to the right (Fig.4) and you should see a small tick next to the top selection 'Display L Channel'.

Since the Audio I/O menu remains displayed, the next step is to click on the Input Sampling Frequency option just below Input Channel Selection. This will cause the first flyout menu to disappear, to be replaced by another giving a list of input sampling frequency options (Fig.5).

If you're using the SILICON CHIP USB Recording/Replay Interface, you can select the 48kHz sampling frequency.

If you're using an interface or sound card which can support 96kHz sampling, this can be selected instead. As a rule of thumb it's a good idea to select the highest sampling frequency that your audio interface is capable of working at, because this will give the best measurement resolution.

Then click on the next menu option, for Output Sampling Frequency, which gives you another sub-menu (Fig.6). This only gives you three options, so select the one which corresponds to the Input Sampling Frequency you chose in the previous step.

The next step is to click on the following option in the Audio I/O menu: CPU Speed Setting. This gives you a menu offering a choice of five speed settings (Fig.7) but it's recommended that during initial set-up you leave it at the default setting of '1 (safest)'. Later on when you are happy that everything is working OK, you can try one of the faster settings.

Your system should now be ready for its initial functional test, so link the Left Line Output of your USB Interface back to its Left Line Input, using a short screened cable with an RCA plug at each end. Then turn your attention to TrueRTA's Generator control panel, a narrow box running down the

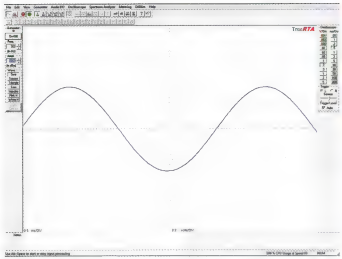


Fig.10: Here's the TruRTA DSO displaying the generator's output signal, with the generator producing a 300Hz sinewave at around -10dBu.

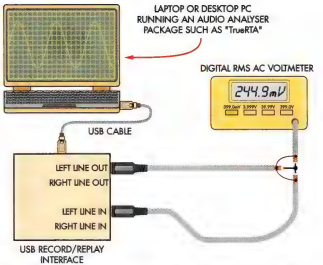


Fig.11: The setup for calibrating the input and output circuitry of your sound card or interface, using an external RMS AC voltmeter.

left-hand side of the screen.

As you can see from Fig.8, this not only offers a Generator On/Off button at the top but small text boxes lower down which can be used to set the software generator's output frequency and output amplitude (in dBu). Then there's a set of buttons providing a choice of waveforms and finally a button labelled 'Quick Sweep'. We'll come back to this button later but for the present just make sure that the generator's frequency is set to 300Hz and its output level to -10dBu.

Now click on the oscilloscope tool button at top left on the screen, just below the File menu – the button with the sinewave on it. Then click on the fourth button along in the same toolbar - the one with the label 'Go'.

This will cause the main window to become TrueRTA's scope display, with its own control panel running down the right-hand side of the screen. As you can see from Fig.9 this gives you two columns of buttons to allow you to set the DSO's vertical gain and timebase scaling, plus a pair of buttons to select either the left or right channels as the timebase triggering source, a slider to adjust the triggering level and a button to select or deselect auto triggering.

For the present, leave the vertical gain and timebase settings at their default values, which should be 0.2V/Div and 0.5ms/Div (as shown in Fig.9). The L channel should also be selected as the triggering source.

At this stage your DSO display should only be showing a horizontal line, because the software generator hasn't been turned on as yet. As soon as you click on the On/Off button at the top of the left-hand Generator panel (Fig.8), you should see the generator's 300Hz sine waveform appear on the display within a second or two (Fig.10).

If everything has gone well so far, you'll now be ready for

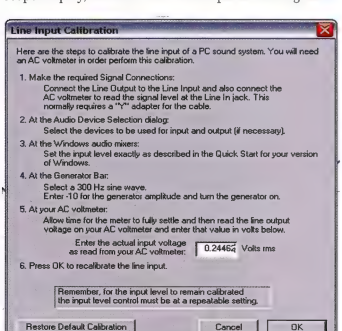


Fig.12: Clicking on Line Input Calibration in the Audio I/O menu (Fig.2) displays this dialog, which is self explanatory.

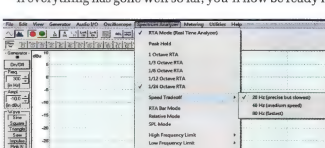


Fig.13 (above): The Spectrum Analyser menu allows you to set the analyser's resolution, its speed/precision tradeoff and measurement limits.

Fig.14 (right): When the analyser is running, its control panel appears at the right-hand side of the screen.

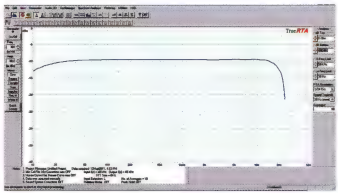


Fig.15: After the initial calibration steps, TrueRTA can measure the overall frequency response of your PC and its sound card or interface.

the next set-up stage: calibrating your system so its audio measurements will be accurate.

By the way, this calibration is necessary because every PC sound card or USB interface tends to have a different sensitivity for its line level inputs and a different line output level.

Calibrating your system

To perform the calibration you're going to need a calibrated AC voltmeter or millivoltmeter, able to give accurate readings of audio levels around 244.62mV RMS (corresponding to -10dBu, since 0dBu = 0.775V RMS).

If you don't have access to an AC millivoltmeter as such, you could use a DMM set to its lowest AC voltage range (many modern DMMs do measure RMS voltage on the AC volts ranges).

The physical set-up for calibration is shown in Fig.11 and again involves the USB Interface's left line output being looped around and fed into the left line input – but this time with the external AC voltmeter monitoring the actual audio level.

The first step is to calibrate the sound card/interface's Line Input circuitry and this is done by first clicking on the Audio I/O menu button to display that menu again (Fig.2). Then run down that menu and click on the item label 'Line Input Calibration...' This will open up the dialog box shown in Fig.12, which as you can see gives you a complete summary of the steps involved in this calibration procedure.

The basic idea is that you first set the software generator

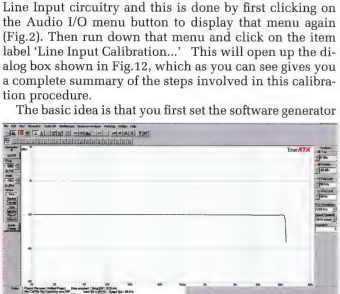


Fig.17: After system calibration, a response plot of the system itself is now virtually 'flat', even when the vertical scaling is expanded.

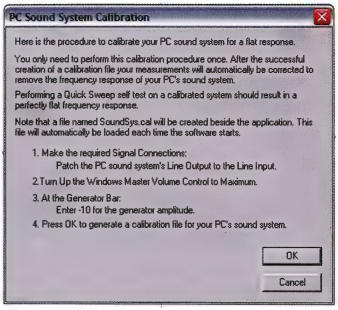


Fig.16: After getting the overall response, the next step is to calibrate the system via this dialog. TrueRTA then produces and saves a frequency calibration curve.

to produce a 300Hz sinewave at a nominal level of -10dBu. Then you turn the generator on (using the On/Off button in Fig.8) and note carefully the reading on your DMM or AC millivoltmeter. It should be somewhere in the vicinity of 245mV or 0.245V but the exact level will depend of course on the line output circuitry in your PC sound card or interface.

Whatever the meter reads, all you have to do is type that voltage value into the text box provided in TrueRTA's opened Line Input Calibration dialog box. Then simply click on the [OK] button at the bottom of the box and TrueRTA will save the line input calibration value so that it will be used in future.

Once you have calibrated the line input circuitry in this way, calibrate the sound card/interface's line output circuitry as well, so the generator's output level will accurately reflect the setting shown in the on-screen control panel.

Line output calibration is done in a very similar way to the line input calibration and using exactly the same physical set-up (Fig.11).

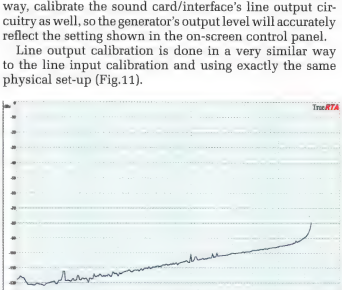


Fig.18: Here's the 'noise floor' plot of the left input channel of our USB Recording/Playback interface. It varies from -120dBu at 15Hz to -90dBu at 20kHz.

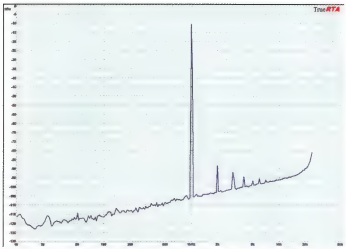


Fig.19: A spectrum analyser plot of the interface when the generator is producing a 1kHz sinewave at -10dBu. Harmonics are visible up to 7kHz.

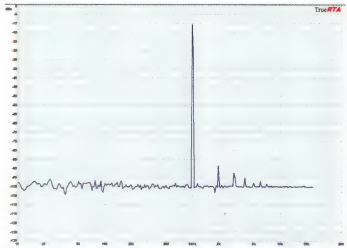


Fig.20: You can get a clearer picture of the sound system's distortion products by subtracting the system noise, as shown here.

The only difference is that instead of selecting 'Line Input Calibration...' in the Audio I/O menu, you select 'Line Out Calibration...'. This again opens up a very similar dialog box to that shown in Fig.12, giving you a summary of the steps in this procedure.

After you have calibrated both the line input and line output circuitry in this way, the next main calibration step is to get TrueRTA to measure the overall frequency response of both the input and output circuitry, so it can save a correction curve for your PC sound system.

Once this is done, any deviations from a flat response in the system itself can be automatically compensated by the software, so your testing of audio equipment in the future will be as accurate as if the PC's sound system response was perfectly flat.

There are basically two steps in this last 'response calibration' procedure, the first of which is to measure the overall frequency response of the PC's sound system. This is done using TrueRTA's spectrum analyser function, in conjunction with its Generator's Quick Sweep button.

The physical set-up remains the same as before, with the Left Line Output looped back to the Left Line Input as shown in Fig.11 (except that the external millivoltmeter is no longer needed).

Just before you do this, you need to switch on TrueRTA's Spectrum Analyser function by clicking on the second tool button from the left-hand end, just below the Edit menu button. This is the button with a little bar-graph symbol on it, alongside the DSO tool's 'sinewave' button.

Then move over to the right and click on the Spectrum Analyser menu button, at top centre of the screen. This will cause the Analyser's drop-down menu to appear, as shown in Fig.13. The purpose of this menu is to allow you to set up the Analyser tool, ready for doing the sound system calibration.

You should find there's a tick alongside the top menu item 'RTA Mode (Real Time Analyser)'. Then you'll need to select the maximum Analyser resolution that's available for your level of TrueRTA – which is 1/24 Octave RTA in the case of level 4, as you can see in Fig.13.

Click on the next menu item down, which is 'Speed Tradeoff', which will bring up a small flyout box. For this calibration job you should select the '20Hz (precise but slowest)' option.

Next check that there is NO tick next to the next menu item down, labelled 'RTA Bar Mode'. This is to ensure that the Analyser will display its results in line graph mode, rather than in bar graph mode.

The Analyser control panel (on the right side) allows you to set the audio level at the top and bottom of the display and also the high frequency and low frequency limits.

It also provides another way to select the RTA Resolution and the Speed Tradeoff, plus you can also type in the number of analyser sweeps you want it to average before the results are displayed.

For this initial system calibration set all these remaining options as follows: Top limit 0dBu, Bottom limit -40dBu, Hi Freq Limit 50kHz, Lo Freq Limit 10Hz and Averages 10.

Make sure that the Generator Ampl level (left side control panel) is set for -10dBu and finally click on the Quick Sweep button at the bottom of the same control panel. After a few seconds you should see a frequency response plot similar to that shown in Fig.15.

This is the overall frequency response of your PC's sound system, at this stage in its 'naked glory', ie, without any correction applied. By the way, the curve shown in Fig.15 is that for the SILICON CHIP USB Recording/Replay Interface.

Now that you have made sure that the Analyser tool is working correctly, it's time to use it to perform the actual sound system calibration. This is done by clicking on the Audio I/O menu button at the top of the screen and then clicking on the 'Sound System Calibration...' item down near the bottom of this menu.

This will cause the PC Sound System Calibration dialog box to appear, as shown in Fig.16.

As before this gives you an easy-to-follow summary of the steps involved in the calibration, so once you've read this all that remains to be done is to click on the [OK] button. TrueRTA will then generate a calibration file for your PC's sound system and save it for use in the future.

If you now do another Quick Sweep, you'll get a somewhat different frequency response plot for your PC's sound system. As you can see from Fig.17, it will now be close to ruler-flat, between the lower frequency limit of 10Hz

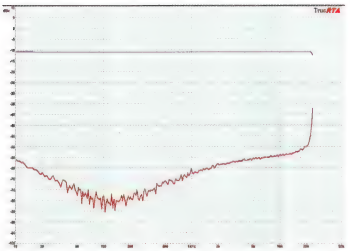


Fig.21: This plot shows the crosstalk into the right channel (lower curve) when the left channel was quickly swept at a level of -10dBu (upper curve).

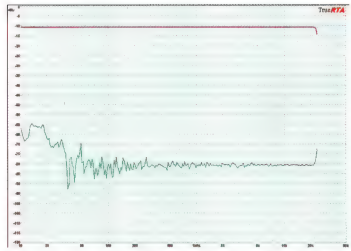


Fig.22: The crosstalk plot of Fig.21 with the right channel's noise floor plot subtracted from it, to show the crosstalk alone (lower curve).

and at least 20kHz. This shows that TrueRTA is now using your Sound System Calibration data to correct the overall frequency response and make it effectively flat.

Your PC and its sound system are now calibrated, at least to the level where you'll be able to carry out quite accurate gain and frequency response measurements on amplifiers, filters, mixers, equalisers and the like.

But as I mentioned earlier, things aren't quite so straightforward when it comes to measuring things like noise, distortion and channel crosstalk. So let's look at these now, to give you a solid grounding of the PC sound system's full capabilities before you move on to practical 'real world' audio equipment testing.

Noise measurement

When it comes to measuring parameters like noise and distortion, in an ideal world you'd be able to use 'perfect' measuring instruments like an AC millivoltmeter or spectrum analyser with no internal noise of its own and an audio signal generator with a 'pure' sinewave output having absolutely no distortion or noise.

But of course such instruments don't exist in the real world, any more than perfect amplifiers or any other kind of equipment. Everything in the real world is imperfect, including test instruments.

That's one of the reasons why high-end noise and distortion measuring instruments tend to be so expensive – because the designers and manufacturers have to put so much time and effort into achieving the lowest possible noise and distortion figures.

So it's probably unrealistic to expect this level of performance from our low cost PC-based measuring system. But just what can we expect?

Well, let's use the Silicon Chip USB Recording and Replay interface as an example.

First of all, look at the plot in Fig.18, which shows the 'noise floor' of the Left line input of the interface with its input taken to ground via a shielded 50Ω resistor. This was measured using TrueRTA of course and the Right line input gave a virtually identical plot.

As you can see the noise generated within the interface's line input circuitry is fairly low but quite significant, rising from around -120dBu at 15Hz slowly up to about -90dBu at about 20kHz and with a few small 'blips' along the way.

Clearly this noise performance wouldn't have a serious effect when you are making noise measurements on equipment with somewhat higher noise levels, say above -70dBu.

But it would certainly result in considerable error if you were trying to make measurements in amplifiers or other equipment with noise levels either comparable with the interface itself, or even better.

Does TrueRTA provide a way of cancelling out the input noise of your PC sound system, so you can make reasonably accurate measurements on low-noise equipment?

Well, it does provide one way to do this, although it doesn't seem to offer an automatic cancellation in the same way it does to correct for the sound system's frequency response.

Instead it allows you to save a noise plot of the sound system itself, like that shown in Fig.18, in one of its memories. Then when you take a noise plot of your low-noise equipment and save it in a second memory, you can use TrueRTA's 'Memory Difference' utility to subtract one plot from the other.

The only complication here is that the resultant plot tends to be displaced vertically, so it can be tricky working out how far to move it up or down using the 'Shift' utility, to restore it to the 'correct' level.

Still, this can give you a reasonable idea of the equipment under test's own noise performance.

TrueRTA's Analyser also offers a 'Relative Mode', whereby once one plot is saved, further plots can be made and displayed in terms of their relative values to the saved plot. This is a bit more like automatic cancellation but it's more suited to tasks like comparing the gain or frequency response between channels, or the effects of tone controls.

Distortion: a little harder

Things do get a little more complicated – read 'tricky' – when it comes to distortion.

That's because the sound system's own circuitry (including the ADCs and the DACs) inevitably introduces some distortion of its own.

Some is introduced by the DACs and line output circuitry,

so the output from TrueRTA's software Generator will not be distortion-free for a start. Similarly, the line input circuitry and ADCs will also introduce some distortion, so our Analyser will not be distortion-free either.

So if you take a noise and distortion plot of the PC sound system itself using TrueRTA's Generator and Analyser, you get a result like that shown in Fig.19.

This plot was taken with the Generator set to produce a 1kHz sinewave at a level of -10dBu and feeding directly from the USB Record/Replay interface's Left line output to its Left line input.

As you can see, it shows the Generator's 1kHz fundamental component in the centre, with a second harmonic 'spike' at 2kHz and third, fourth, fifth, sixth and seventh harmonic spikes visible as well, at levels varying from -87dBu down to -94dBu.

Of course these are also sitting on the Interface's noise plot, which tends to make them seem worse than they are.

But you can get a clearer picture of the distortion components by subtracting the interface's own noise plot from it, to produce the plot shown in Fig.20. This was done using TrueRTA's Subtract utility to subtract the interface's noise floor plot from the distortion and noise plot of Fig.19 (and then moving the resultant back down into the correct range using its Shift utility).

This '(D+N) - N' plot does give a somewhat clearer view of the sound system's overall distortion performance, as you can see, although TrueRTA doesn't provide a utility for using this information to calculate the total harmonic distortion (THD) as a percentage.

All it gives you is a table in the User's Guide showing the relative distortion figures for harmonic levels from -5dB to -120dB below the fundamental.

So if you want to calculate the THD you have to do this yourself, by finding the percentage levels of the various harmonics and then doing a 'square root of the sum of the squares' calculation. I did this myself using the plot of Fig.20 as a starting point and found the THD to be around 0.017% – not too bad but clearly not wonderful either.

Of course even when you have done this somewhat tedious calculation, the figure you get is not all that useful when it comes to measuring the distortion performance of external equipment.

You could get a 'rough estimate' of the equipment's THD by using TrueTHD to do a plot of its distortion at 1kHz, working out an equivalent THD figure and then subtracting the system's own THD figure from it but this would not be particularly accurate. In any case it would be for only one frequency.

It would be very tedious to repeat this procedure for many different frequencies, which would be needed if you wanted to produce a full distortion plot. I think we can therefore conclude that it's not really feasible to use a software package like TrueRTA to produce a full THD plot for relatively low distortion audio equipment like amplifiers, preamps and filters.

You would be able to use it to produce spectrum plots like that in Fig.20, to give you a rough idea of the equipment's distortion at different frequencies.

Of course using TrueRTA with a calibrated microphone, you would be able to plot the distortion of higher-distortion acoustic equipment such as loudspeaker systems. That's because with these, the sound system's own distortion performance would be so much better than that of the gear being measured, you could safely ignore it.

Summarising

On the whole then, it's fair to say that a PC-based audio testing system using a software package like TrueRTA together with a good quality sound card or USB interface is capable of making quite accurate measurements of the gain and frequency response of things like amplifiers, preamps, filters, equalisers and mixers.

It is also capable of making reasonably accurate noise plots of the same equipment, together with spectrum analysis plots of the distortion at specific frequencies.

But it's not really capable of being used to provide THD or THD+N plots and its utility in plotting inter-channel crosstalk is quite limited.

Still, it's a big step forward being able to measure the frequency response and noise performance of this kind of equipment. SC

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USB MIDI-Mate

An up-to-date MIDI interface for PCs

Use your PC to link up MIDI synthesisers, keyboards and various instruments. Most modern PCs make good sequencers for electronic music making, with readily available software and the drivers built into the latest versions of Windows. This USB-MIDI interface provides all the hardware you'll need.

By JIM ROWE

TEN YEARS AGO, in the February 2001 issue of SILICON CHIP, we described a project called the MIDI-Mate – an easy-to-build MIDI interface to go with the PCs that were then available. At that stage, most PCs had either no built-in MIDI port at all or just a rudimentary MIDI port tucked away inside their sound card and available only via a couple of pins on the sound card's game port.

The original MIDI-Mate was designed to expand those crude MIDI "core ports" into a full MIDI port which could be hooked up to any standard MIDI synthesiser, instrument or keyboard using standard MIDI cables. The unit was pretty popular and we think this updated USB version will be too.

Now it's true that basic USB-MIDI adaptor cables are already available at fairly low cost, offering a MIDI IN and MIDI OUT port at the end of a cable which plugs into a PC's USB port. But these devices only offer the bare minimum of MIDI interfacing facilities. There's no MIDI THRU output linked to the MIDI IN jack and only a single MIDI OUT jack, which restricts you to a very simple set-up.

Our aim in developing our new USB MIDI-Mate has been to come up with an up-to-date interface offering the same expanded MIDI ports as our original unit. At the same time, the cost should be only slightly higher than a USB adaptor cable.

As with the original MIDI-Mate, it's powered directly from the PC so no separate power supply is needed.

What it does

This unit provides a 2-way serial communications "bridge" between one of the USB ports on a PC and external MIDI devices. This enables the PC to send a MIDI music file out to a synthesiser and/or other electronic musical instruments via the interface's MIDI OUT jacks. In addition, the PC can receive MIDI messages from a keyboard or other MIDI controller, via the interface's MIDI IN jack.

The rear panel provides access to the Type-B USB socket and a reset switch. The two LEDs show the USB status and blink alternately when the device is plugged into a computer and working correctly.

Both the MIDI IN and MIDI OUT messages are relayed to and from the PC (and the software running on it) via a single USB cable.

Considering that USB is a serial bus and MIDI is also serial data communication, you'd perhaps expect that an interface bridging between the two would be quite straightforward – a bit like a couple of UARTs (Universal Asynchronous Receiver Transmitters) connected back-to-back. It's not quite that easy though, largely because of the protocols that must be used when any kind of data is sent over the USB.

That's because all USB communication is controlled by the host (ie, the PC) and the device at the other end of a USB cable is not free to upload any data it likes, whenever it likes.

In addition, each MIDI message sent over the USB needs to be "packetised" (packaged into a standard USB data packet) with an identifying header byte attached to the start of the packet – a bit like an address label. This is to ensure that each packet reaches the correct destination at the receiving end.

Quite apart from these complications, any USB device also has to provide answers to a standard set of questions from the host PC as soon as it's plugged into a USB port. This rigmarole is known as the "enumeration sequence", because the host needs to know quite a lot about the device before it can give it a USB address and install the appropriate drivers so its software can communicate with the device correctly.

Parts List: USB MIDI-Mate

1 PCB, code 23110111, 117 x 102mm
1 low-profile instrument case, 141 x 110 x 35mm
4 5-pin DIN sockets, 90° PCB-mount
1 SPST momentary tactile push-button switch, 90° PCB-mount (S1) (Jaycar SP-0607)
1 12MHz quartz crystal (X1)
1 Type B USB socket, PCB-mount (CON1)
4 5-pin DIN sockets, 90° PCB-mount (CON2-CON5)
1 6-way section of SIL pin strip
1 18-pin DIL IC socket
1 14-pin DIL IC socket
1 8-pin DIL IC socket
4 small self-tapping screws, 6mm long
1 M3 x 6mm machine screw with M3 nut & washer
100mm tinned copper wire for links

Semiconductors
1 PIC18F14K50 microcontroller programmed with 2311011A.hex (IC1)
1 74HC04 hex inverter (IC2)
1 6N138 optocoupler (OPTO1)
1 IRF9540 P-channel MOSFET (Q1)
3 3mm red LEDs (LED1, LED3, LED4)
1 3mm green LED (LED2)
1 1N4148 diode (D1)

Capacitors
1 10µF 16V RB electrolytic
1 470nF MKT metallised polyester
2 100nF MKT metallised polyester
2 22pF NP0 ceramic

Resistors (0.25W 1%)
1 33kΩ
1 10kΩ
2 470Ω
2 330Ω
9 220Ω
1 47Ω
1 2.2Ω

In short, even though our little USB-MIDI interface is just acting as a 2-way communications bridge, it needs to be based around a microcontroller to handle the USB enumeration and communications protocols. In this case, we're using a PIC18F14K50 microcontroller, which is about the smallest and lowest-cost device available with an in-built USB module, as well as a USART module capable of working at the MIDI data rate of 31.250kHz.

The USB module inside the PIC18F14K50 is actually pretty impressive. It includes a full-speed and low-speed compatible USB serial interface engine (SIE) plus a USB transceiver so that it can connect directly to a USB cable. It takes its clock signals from the PIC's main clock circuitry, which in this case also includes a frequency-multiplying phase-locked loop (PLL) to provide a 48MHz clock derived from the external 12MHz crystal.

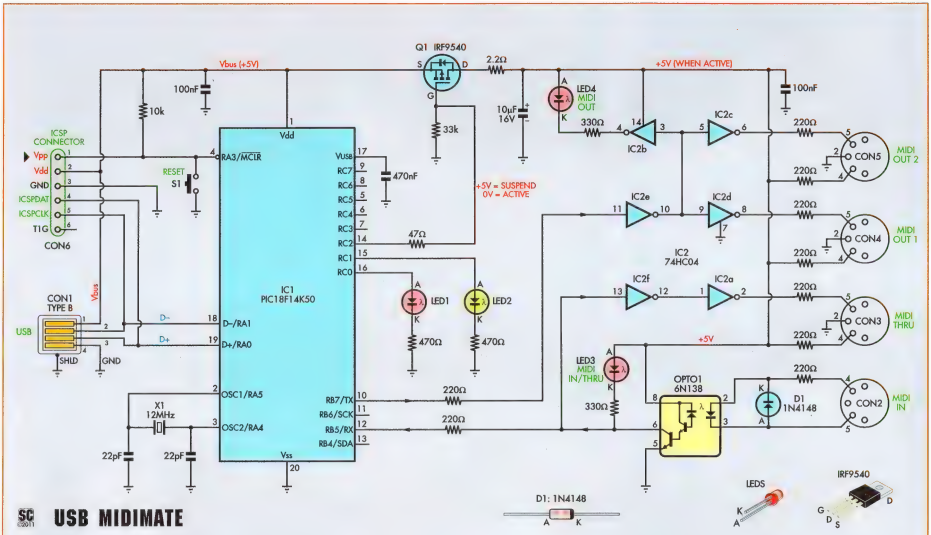


Fig.1: the circuit is based on a PIC18F14K50 microcontroller (IC1) which handles USB enumeration and exchanges MIDI data packets with the PC via USB connector CON1. The 6N138 optoisolator (OPTO1) provides the necessary isolation for the MIDI IN socket, while inverters IC2a & IC2c-IC2f buffer the signals to the MIDI OUT & MIDI THRU sockets. IC2b drives LED4 which blinks when there is activity on the output sockets, while Mosfet Q4 switches off the power to IC2 and OPTO1 when the PC (via IC1) instructs the device to enter "suspended" mode.

The MIDI Standard: What It Is & How It Works

MIDI is an acronym standing for *Musical Instrument Digital Interface*. It's a standardised system for communicating between electronic musical instruments, keyboards, controllers and sequencers (including PC-based sequencers). The MIDI standard was agreed on by a group of musical instrument makers in 1983 and has been used and extended since then.

MIDI relies on serial data communication at 31.25kb/s using asynchronous 5mA current loop signalling, with the current provided by the "transmitting" end. This means that each byte of a MIDI message takes only 320µs to be transmitted (counting start and stop bits). Since MIDI messages are either one, two or three bytes in length, this means that over 1000 such messages can be sent each second via a single MIDI cable.

Each MIDI cable carries only one signal, so for bi-directional communication, two cables must be used. The cables themselves use shielded 2-conductor wire. All MIDI cables are fitted with standard 180 ° 5-pin DIN plugs at both ends. However, only pins 4 & 5 are used for the actual current loop signalling (wired 4-4 and 5-5). Pins 1 & 3 are left unconnected, while the shield braid is connected to pin 2 at each plug.

Inside MIDI equipment, pin 2 is connected to earth only on MIDI OUT sockets. This allows correct earthing of the cable shield braids, without creating earth loop problems.

Unlike most other current-loop signalling, current only flows in a MIDI link when data is actually being transmitted. This allows MIDI cables to be plugged and unplugged without any problems, as long as data is not actually being transmitted at the time.

To prevent equipment damage due to wiring errors or component faults, all MIDI inputs are provided with 3kV of galvanic and electrostatic isolation via an optocoupler. For correct MIDI communication between equipment, a MIDI OUT or MIDI THRU socket at one end must be connected to a MIDI IN socket at the other.

In most MIDI systems, there is a single main controller or sequencer (often the computer), from which most of the MIDI messages originate. When these messages must be sent to more than one instrument, they can be distributed in either "star" or "daisy-chain" manner as desired.

There's no need to worry much about the actual code messages sent over the MIDI links, because nowadays this is all handled by sequencer or other software running in the PC and by firmware running in the other instruments and keyboards. It's probably enough to know that most MIDI messages are short commands to allocate a particular instrument to a particular channel, to tell it to start or stop playing a particular note, to change the instrument's attack/decay or other performance parameters, and so on.

As mentioned earlier, these commands are generally in the form of three-byte messages, although some configuration and/or system management messages are only one or two bytes long.

Using a PC-based music editing and sequencer program, and perhaps with a MIDI music keyboard to feed in the actual notes, you can assemble a complete sequence of MIDI commands to play a piece of music – eg, on the "instruments" in a synthesiser. The synthesiser can then be made to "perform" that piece of music simply by sending the sequence to it, via the MIDI link.

When you're happy with the result, you can save the sequence on disk as a MIDI music file. These have a standardised format and are identified with a ".MID" extension. Discs with collections of pre-composed MIDI music files are also available and you can download them from the internet as well.

It's important to realise that although a MIDI music file may look superficially similar to a .WAV file of a digital sound recording, it's really quite different. It's more like an electronic equivalent of sheet music – simply a sequence of detailed instructions describing how to play the music. In this case, it's instructions for electronic instruments rather than for human players.

Finally, if you do want to delve more into the technicalities of MIDI, you'll find quite a bit of useful reference information on the MIDI Manufacturers Association website at **www.midi.org/techspecs**

There are also some very helpful detailed explanations at **home.roadrunner.com/~jgglatt/tech/midispec**

Data can be exchanged very efficiently between the PIC's CPU and the USB module's SIE. That's because they share a 256-byte dual-port static data RAM (SRAM), with each side controlling one of the ports.

Circuit description

Now refer to the full circuit shown in Fig.1. The heart of the circuit is IC1, the PIC18F14K50. This does all the real work of the interface, exchanging data packets with the PC via USB connector CON1 which connects directly to pins 18 & 19, the transceiver pins of the PIC's USB module.

On the MIDI side, the outgoing MIDI messages from the PC emerge from pin 10, which is the serial data output of the PIC's USART module. Incoming MIDI messages enter the PIC via pin 12 – the USART module's serial data input.

The rest of the circuitry outside IC1 is mainly used to condition the incoming and outgoing MIDI messages. This is necessary because the MIDI system uses current-loop transmission and requires all inputs to be provided with high-voltage isolation using an optocoupler. OPTO1, a 6N138 high-speed device, provides the necessary isolation for the MIDI input jack CON2. It also acts as a current-to-voltage converter so that incoming MIDI messages are converted into voltage levels to feed pin 12 of IC1.

By the way, don't be tempted to try substituting another optocoupler for OPTO1. Most other optocouplers don't have the switching speed of the 6N138 and won't give reliable transfer of MIDI signals.

Two of the inverters inside IC2 (a 74HC04 hex inverter) are used to take the incoming MIDI messages from pin 6 of OPTO1 and convert them back into current-loop form to drive the MIDI THRU output jack (CON3). Three of the remaining inverters are then used to convert the outgoing MIDI voltage-level signals from pin 10 of IC1 into current-loop form to drive the two MIDI OUT jacks CON4 and CON5.

The remaining inverter is used to drive LED4, which blinks to indicate activity on the MIDI output jacks.

LED3, which is connected in series with the output load of OPTO1, provides the same kind of activity indicator for the MIDI IN and MIDI THRU jacks.

The two remaining LEDs in the circuit, LEDs1 & 2, are driven directly from pins 15 & 16 of IC1. These are used to indicate the USB status of IC1 and hence the status of the interface as a whole. When the interface is correctly enumerated and configured for

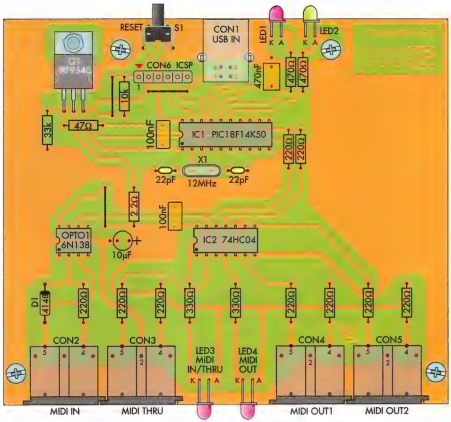


Fig.2: here's how to install the parts on the PCB. Make sure that IC1, IC2 and OPTO1 are correctly orientated and check that all sockets are flush against the board before soldering their leads.

use, these LEDs blink alternately at about 1Hz.

Power supply

As mentioned earlier, the interface circuit receives its power from the host PC via the USB cable, so it's a "bus powered" device. IC1 is powered directly from the Vbus line (pin 1 of CON1), while IC2 and OPTO1 receive their power via Q1, an IRF9540 P-channel Mosfet used here as a switch under the control of IC1 via pin 14 (RC2).

The idea behind this is that all bus-powered USB devices must reduce their total current drain to a very low level when the host PC sends them into suspended mode. It does this by simply not sending them any "stay awake" token packets for a period of 3ms or more. In this circuit, as soon as IC1's USB module senses that it should enter suspended mode, it turns Q1 off and thereby switches off the power to IC2 and OPTO1.

When the PC directs IC1 to "wake up", it switches Q1 back on again and restores power to IC2 and OPTO1. The average current drawn by the interface circuit from the host PC via the USB cable when it's not suspended and operating is around 22mA.

Crystal X1 on pins 2 & 3 of IC1 is the resonator for the PIC's main clock oscillator, while switch S1 is provided to allow manual resetting of the PIC, if this should ever be needed. The only other item that we haven't as yet mentioned is CON6, a 6-pin SIL pin strip which provides an ICSP (In Circuit Serial Programming) interface. This allows the PIC to be programmed in-circuit using a programmer like Microchip's PICKit3.

Construction

All the components used in the USB MIDI-Mate are mounted on a single PCB coded 23110111 and measuring 117 x 102mm. This mounts inside a standard low-profile plastic instrument case measuring 141 x 111 x 35mm. The Type-B USB connector CON1 used to connect the interface to the host PC is mounted in the centre along the rear edge of the board, with LEDs1 and LED2 on one side and S1 on the other.

The four 5-pin DIN sockets used for the MIDI jacks (CON2-CON5) are spaced along the front edge of the board, with LED3 and LED4 in the centre. All connectors and LEDs (together with S1) are accessed via matching holes in the rear and front panels.

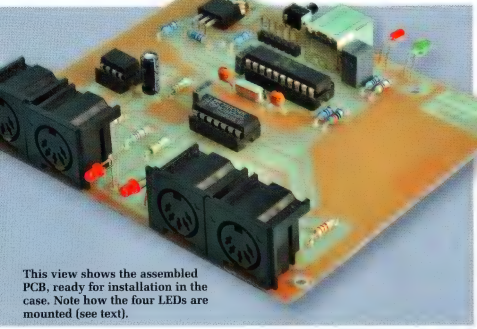
Fig.2 shows the parts layout on the board. Fit the wire links, resistors and capacitors first, then fit Mosfet Q1. The latter comes in a TO-220 package and mounts flat on the top of the board at upper left, with all three leads bent downwards by 90° about 6mm from its body. Its tab is then fastened to the board using an M3 x 6mm machine screw, washer and nut, after which the leads are soldered to their PCB pads.

Capacitor Codes

Value	µF Value	IEC Code	EIA Code
470nF	0.47µF	470n	474
100nF	0.1µF	100n	104
22pF	NA	22p	22

Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	2	330Ω	orange orange brown brown	orange orange black black brown
❑	9	220Ω	red red brown brown	red red black black brown
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	2.2Ω	red red gold brown	red red black silver brown



This view shows the assembled PCB, ready for installation in the case. Note how the four LEDs are mounted (see text).

The USB connector (CON1) and the four DIN sockets (CON2-CON5) can now go in. Make sure they all sit flush against the PCB before soldering their pins. You can then fit the three sockets for IC1, IC2 and OPTO1, followed by pushbutton switch S1 and the 6-pin SIL strip (CON6).

The four LEDs are next on the list. The two red LEDs between the MIDI sockets should first have their leads bent down through 90° some 5mm from their bodies. These LEDs are then installed so that the horizontal sections of their leads are 11mm proud of the board (use an 11mm-wide cardboard spacer to set this).

Similarly, the red and green LEDs adjacent to the USB connector (CON1) have their leads bent down through 90° about 3mm from their bodies. These LEDs are then installed 7mm proud of the board.

If you are building the USB MIDI-Mate from a kit, the PIC18F14K50 microcontroller will have been pre-programmed with the correct firmware. However, if you're building the project from scratch, you'll either have to purchase a programmed PIC-18F14K50 from SILICON CHIP Publications or program it yourself.

If you do elect to program it yourself, the firmware (2311011A.hex) can be downloaded from the SILICON CHIP website.

The PCB assembly can now be completed by plugging the two ICs and OPTO1 into their respective sockets. All three are orientated with their notched ends to the left.

Installing the board into the recommended case is straightforward. Fig.3 shows the drilling templates for the front and rear panels. Once the holes have been drilled, reamed and filed to shape, download the two panel artworks (in PDF format) from the SILICON CHIP website and print them out. The labels can then be laminated and attached using doubled-sided adhesive tape. Cut out the holes in the labels using a sharp hobby knife.

That done, the PCB assembly can be lowered into the bottom half of the case along with the front and rear panels. It's secured using four 6mm-long self-tapping screws, which mate with four of the moulded mounting pillars.

Your USB MIDI-Mate is now complete and ready for use. There are no adjustments or setting up needed; if you have assembled it correctly, it should be ready for use immediately.

Plug and play

As soon as you connect the USB MIDI-Mate to a PC running Windows XP (SP3), Vista or Windows 7, Windows should detect it and go through the USB enumeration process before finally indicating that the device is ready to use. If you then glance at the rear of the interface, you should see that LED1 and LED2 are blinking on and off alternately. This indicates that the USB MIDI-Mate is enumerated, "awake" and ready for business.

You can also confirm that everything

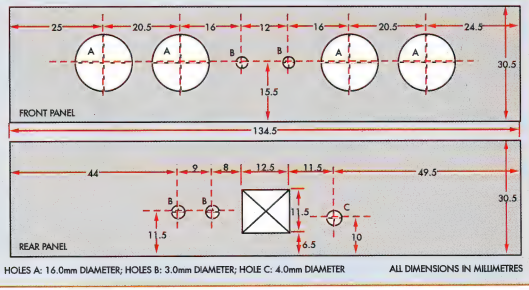


Fig.3: this drilling template for the front and rear panels can be downloaded (in PDF format) from the SILICON CHIP website. Use a small pilot drill to start the holes before enlarging them to the correct sizes (see text).

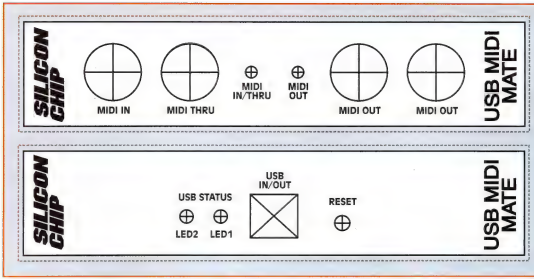


Fig.4: these front and rear panel labels can be downloaded in PDF format from the SILICON CHIP website. They should be laminated and attached to the panels using double-sided adhesive tape.

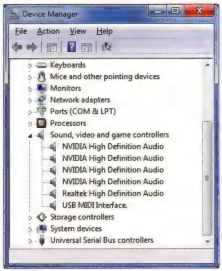


Fig.5: when connected to a PC, the unit should appear in Device Manager as a "USB MIDI Interface".

Fig.6: in Windows XP, "USB Audio Device" should be listed here as one of the MIDI Music Playback devices.

Fig.7: "USB Audio Device" should also appear in this list when the Hardware tab is clicked (XP).

is correct by checking the Device Manager settings. For both XP and Windows 7, launch Device Manager (via the Control Panel) and expand the "Sound, video and game controllers" listing. You should see "USB MIDI Interface" listed – see Fig.5. If you then right-click this entry and click Properties, you should see a dialog telling you that "This device is working properly".

Note that if you are using Windows XP, it may be necessary to allow the operating system to search the Internet for a suitable driver to install when the interface is initially connected. Once it's installed, it should show up in Device Manager. In addition, if you open Control Panel, double-click "Sounds and Audio Devices" and then click on the Audio tab, you should see "USB Audio Device" listed as one of the MIDI Music Playback devices (see Fig.6).

If you now click on the Hardware tab, you should find the "USB Audio Device" listed there as well. If you select this and click on the Properties button, its Location should be shown as "Location 0 (USB MIDI Interface)". And in the Device Status box, you should again see the message "This device is working properly".

The software to use

Since the USB MIDI-Mate is compliant with the USB and MIDI specifications, it works fine with any of the common MIDI music player and sequencer applications. While developing and testing the project, we used two applications that can be downloaded for free – "Notation Player" and "Anvil Studio 2011".

Notation Player is a MIDI music player application that can be downloaded at no cost from **www.notation.com** It not only lets you play virtually any MIDI music file but also shows the file's musical notation on the screen while it's playing.

Anvil Studio 2011 is a bit more elaborate. It's not only a MIDI music player but a recorder and sequencer as well. Written by Willow Software, it can be downloaded free from **www.AnvilStudio.com**

As well as displaying a MIDI music file's notation on the screen, Anvil Studio 2011 will also let you check your MIDI OUT and MIDI IN connections via the USB MIDI-Mate, show-

The PCB assembly is secured inside the case using four self-tapping screws which go into integral pillars.

ing you the MIDI messages on-screen at the same time. This is very handy for troubleshooting MIDI cables and instruments, etc.

Assuming that you have a synthesiser or other MIDI instrument connected to the USB MIDI-Mate, getting it to "play" should now simply be a matter of starting up your player or sequencer application, loading a MIDI file and then clicking on the "Play" button. While the file is playing, LED4 on the front panel should blink as the MIDI messages stream out to the synthesiser.

Similarly, if you have a MIDI music keyboard or other controller, you'll now be able to hook its MIDI OUT to the MIDI IN jack on the USB MIDI-Mate and record your own music to the computer's hard disk – after clicking on the sequencer program's "Record" button, of course.

And that's really all there is to it. With the USB MIDI-Mate and a suitable application like Notation Player or Anvil Studio 2011, your computer will have everything it needs to become a powerful MIDI music player and/or sequencer.

The rest is up to you and your musical creativity. SC

The two USB Status LEDs, the USB socket and the Reset switch are accessed via the rear panel.

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Need to upgrade from Protel Autotrax or Easytrax?

CadSoft EAGLE could be the answer

By NICHOLAS VINEN

If you are new to PCB design or you are an old fogey stuck in a time warp with DOS and Protel Autotrax or Easytrax, now is your chance. Now you can get CadSoft EAGLE which works under the Windows, Linux or Mac operating systems. You can even get a limited version (EAGLE Light) which is available for non-profit use at no charge. You can then give DOS the flick.

IF YOU ARE a rank beginner but reasonably familiar with Windows (or Linux or Mac) software which makes extensive use of the graphical interface, then CadSoft EAGLE is reasonably easy to learn. And if you are a long-time fan of Easytrax or Autotrax, you will find much that is similar in Eagle, with drop-down menus, component libraries, schematic editor and so on.

Some of the contributed projects published in SILICON CHIP have been designed with Eagle, especially using the free version which can cope with a maximum PCB size of 100 x 80mm. If you want more CAD power, upgrades are reasonably priced and within the hobbyist's reach.

But EAGLE is also a serious design package which can be used on a commercial scale. It can accommodate multiple large, complex boards with many surface-mount and through-hole parts, based on circuits spread over many sheets.

How To Obtain CadSoft Eagle

CadSoft EAGLE is available from Element14 (**au.element14.com**) or from the CadSoft website (**www.cadsoftusa.com**). There are four versions with some options:

(1) EAGLE light: one schematic and up to two layers per board; maximum dimensions 100 x 80mm. Free for non-profit use or evaluation purposes. Or $54.45 with fax and telephone support.

(2) EAGLE Hobbyist: 99 schematics and up to six layers per board; maximum dimensions 160 x 100mm. For non-commercial use only. US$125.

(3) EAGLE Standard: 99 schematics and up to six layers per board; maximum dimensions 160 x 100mm. Price varies by number of users and options. $553.34 for one user with schematic and PCB layout, $830.00 with auto-router.

(4) EAGLE Professional: 999 schematics and up to 16 layers per board; maximum dimensions 1.6 x 1.6m. Price varies by number of users and options. $1106.67 for one user with schematic and PCB layout, $1660.00 with auto-router.

Discounts are available for educational users. Note: prices do not include GST.

Features

EAGLE's primary parts are the schematic (circuit) editor, PCB layout editor, component library editor, autorouter and CAM (computer aided manufacturing) facility. It also has a "script" feature which adds a number of very useful options, such as making mass changes to boards and schematics.

The first step in any PCB design is to draw the circuit and you do that using the schematic editor (see Fig.1).

The main controls are arranged in a toolbar down the left side of the screen, although you can move it about if you wish.

The toolbar includes buttons to add a component, move it, rotate it, duplicate it, delete it, change its name (designator) and value, swap sub-components (eg, op amp sections) and pins, route nets and so on. There are 36 standard tools.

There is also a "command line" at the top of the window where commands can be typed. This gives you access to more advanced options (eg, rotating components by angles smaller than 90°). But all the most common commands are available via the toolbar, menus or keyboard shortcuts (which can easily be customised).

Component libraries

One of the biggest obstacles to starting out with any CAD package is gathering together a comprehensive set of component libraries. You will need resistors, capacitors, diodes, transistors, ICs, inductors, transformers, relays, pushbuttons, switches . . . the list goes on. It's frustrating if you must spend a lot of time adding components to the library before you can draw a circuit.

Fortunately, EAGLE comes with a large number of component libraries (314 at last count!). Some of these are manufacturer-specific (eg, one contains around 200 Analog Devices ICs) while others are generic, eg, common diodes and transistors. Then there is the "rcl" library which includes most common types of resistors, capacitors and inductors (through-hole and surface mount).

This makes for a great start. Inevitably, you will need to add library elements for special purpose ICs and so on. But there are many EAGLE libraries available free on the internet too. For example, libraries with Microchip and Atmel microcontrollers can be found quite easily and installing them is just a matter of downloading the file(s) into the right directory.

Adding custom parts is pretty straightforward. The library editor interface is similar to that of the PCB editor (described later). You can copy an existing part into your own library (with a couple of clicks) and then modify it. Since there are so many existing parts, quite often that's all you need to do. You can also make a part from scratch based on a dimensional drawing in a data sheet.

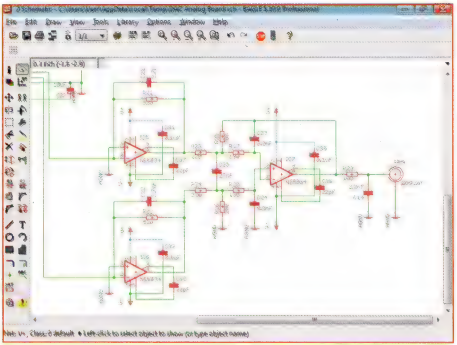

Fig.1: the schematic (circuit) layout editor, showing a portion of the SILICON CHIP DAC circuit (September-November 2009). The toolbar is at the left and the V+ power supply net is highlighted using the "show" tool (eye icon).

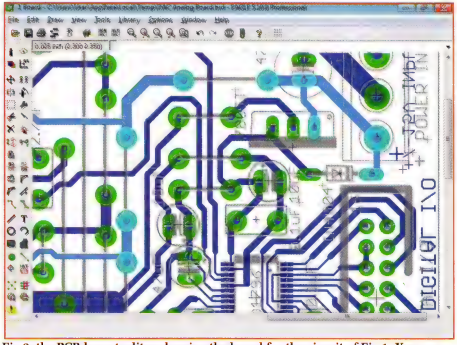

Fig.2: the PCB layout editor showing the board for the circuit of Fig.1. You can see that the tracks forming the V+ net are also automatically highlighted. As with the circuit editor, there is a toolbar on the lefthand side but it has more and different buttons.

EAGLE components consist of three basic pieces. The first is the footprint (ie, how it appears on the PCB) and this can often be copied verbatim from the "reference packages" library, which contains around 1000 common component footprints.

The second piece is the symbol, shown in the circuit diagram. The simplest method for custom ICs is to just draw a box and then arrange pins around it.

Finally, there is the component entry itself which ties one or more

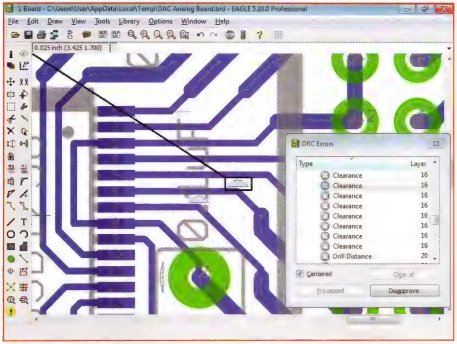

Fig.3: using the Design Rule Check feature on a PCB layout. You define the design rules (in this case, track-to-track clearance) and it flags any violations.

symbols to one or more footprints. If a component has multiple symbols these are postfixed with letters (eg, IC1A, IC1B etc). If there are multiple footprints, they have different suffixes. For example, "LM358" could have DIP8 (LM358N) and SOIC8 (LM358M) footprints.

Each symbol/footprint combination can have its own pin mapping, avoiding the need to create different symbols just because the footprint pin configurations differ. This doesn't quite work if the packages have extra electrical connections (eg, multiple ground pins or a conductive tab). In general though, the system works well.

Perhaps the biggest limitation of EAGLE's component system is that component footprints can't be modified in the PCB as you design it. The pad sizes and shapes can be overridden but it is an all-or-nothing deal so if one particular resistor needs smaller pads or a different pad spacing, you have to create a new library element. We found that it is possible to work around this by creating a few different versions of common parts.

With so many libraries in the system, one invaluable feature is the component search. When adding a component you just type a few letters, such as "diode" or "tl07*" and press enter. The list of available components then shows just those which match. This is generally a much faster way of finding the right component than wading through the library hierarchy.

Schematic editor

Drawing the circuit is just a matter of importing the components you need and wiring them up.

One handy feature is the automatic component numbering. For example, the first resistor you place is named R1, the second R2 and so on. You can change these to whatever you like but component names must always be unique. This makes sense but it can be a pain if you need to renumber them.

One possibility is to ignore component names initially and then use one of the provided scripts to automatically renumber them based on their location on the PCB, eg, left-to-right and top-to-bottom. That's a time saver! There are 128 scripts like this provided with the program and more can be created or downloaded.

For parts with multiple sub-sections (eg, digital logic ICs or dual/quad op amps), they are placed individually but their name (designator), value (component type) etc are linked. Sections within an IC can be swapped in the circuit with a couple of clicks as can interchangeable pins (eg, inputs to a logic gate). This is very handy during the layout stage as you can easily adjust the connections to simplify the routing.

For many of these ICs, the power supply pins are placed separately. This can look a bit strange but makes the wiring less cluttered. In some cases, the power supply pins can be dropped on top of one of the other sections (op amp, logic gate, etc) which makes for a neater result.

Unfortunately, the EAGLE libraries do handle power pins inconsistently; some parts have separate power pins and for others they are fixed. But you can use the library editor to change them to suit your needs.

Nets

A net is a set of component pins which are electrically connected. It can have a name (eg, "GND" or "V_{CC}"). A "netlist" consists of one or more nets and together with a list of components, defines a circuit. Why "net"? Well if you drew lines between all pins that are to be joined, the resulting set of crossed lines would look something like a net.

To define the nets for a circuit, you draw lines between pins to form either nets (thin lines) or buses (thick lines). Buses collapse multiple nets into a single visual representation, reducing clutter on the circuit diagram.

Rather than drawing a line from one pin to another to put them in the same net, you can connect them to separate lines but then set those to be the same net. Nets can be labelled on the schematic and you would certainly do so if using this technique, otherwise it's unclear which pins are in which nets.

Connecting pins to a power supply symbol (eg, GND or V_{CC}) automatically changes the net name to match the power supply. Therefore any pins connected to the same power supply symbol are automatically part of the same net.

There is a clever feature which allows some component pins to be automatically connected. Say you have an IC with V_{CC} and GND pins. By default then, these are automatically connected to the V_{CC} and GND nets.

Unfortunately this doesn't always work; some parts may have pins labelled V_{DD} and V_{SS} but you may need to connect them to V_{CC} and GND. In this case, you can simply add explicit power pins and wire them up as necessary. We prefer this approach as it's harder to make a mistake.

EAGLE includes a basic circuit error checker ("ERC"). It can't detect all problems but it can spot obvious

ones. This includes unconnected inputs or power supply pins, shorted power supply rails, nets with only one pin in them (or none), nets with open collector and push-pull outputs joined, multiple push-pull outputs joined (sometimes valid, sometimes not) and so on.

One handy feature is the ability to copy and paste sections of the circuit, for cases where similar circuitry is repeated. In fact, EAGLE can apply most of its commands to a selected portion of the circuit or PCB which can be a real time saver.

PCB layout

Having drawn a circuit, you can then proceed to the PCB layout. All the components automatically appear outside the board outline with a yellow "rat's nest" of lines showing which pins/pads are to be connected, according to the circuit. Components and tracks snap to a grid which may be set in imperial or metric units and you can swap between two different grids (eg, coarse and fine).

At this point, if any parts are in the wrong package, changing to an alternative package is simple. This is handy for changing the pin spacing for passive components as necessary. You can also alter the names (designators) and descriptions (type/value) during layout.

One very nice feature is the ability to turn off component names and values en masse, greatly reducing the visual clutter. Once the layout is complete you can turn them back on and move them to their final locations.

All changes made during layout are automatically mirrored on the circuit diagram; there is no need to synchronise them separately. This is convenient but you must be careful when making changes to the circuit once the board is laid out.

For example if you delete a connection between components, the corresponding PCB track will automatically be deleted ("ripped up"). Sometimes this is what you want but if you're just trying to rearrange the nets on the circuit, it's best to draw the new connection before deleting the old one so you don't have to redraw the track afterwards.

It's also very easy to highlight a net or component in either the circuit or PCB layout and have it light up in the other (see Figs.1 &2). This makes tracing tracks and identifying components a breeze.

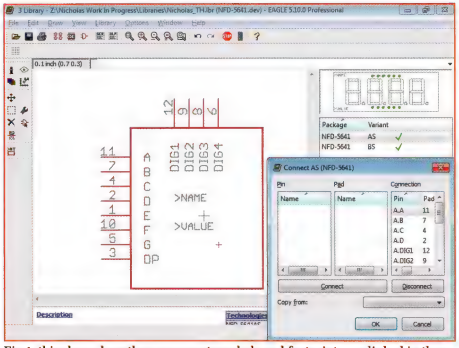

Fig.4: this shows how the component symbols and footprints are linked in the library editor. In this case, we have a 7-segment LED display symbol with two package variants.

Routing

Routing involves connecting all the appropriate component leads together using tracks (representing copper on the final board). This is a similar process to drawing nets, ie, you draw lines on the PCB but this time they are not conceptual but actually define the physical layout. The end result of the routing process is a PCB pattern.

EAGLE has an auto-router which is present in the free version (EAGLE Light) but if you want it in the full version, it costs extra. It is basic but certainly does the job. You can assign the "cost" of tracks on different layers, vias etc and it will find a way to connect all nets (if possible) within the design rules (ie, without violating manufacturing restrictions like track widths and clearances).

While it's quite capable, we still prefer to route PCBs manually. The auto-routed layout is a good starting point but it doesn't do much "glossing" (minimising tracks lengths, rounding corners etc). It also doesn't use thicker tracks where higher currents will flow because it doesn't know; it's also unaware of the need for star earthing etc. In short it's handy but won't do the PCB layout work for you.

Manual routing can be quite quick and easy since there are various shortcuts. For example, while drawing a track, right-clicking the mouse cycles through the various track and corner styles (right angle, 90°, rounded, snaking etc). If you change layers while routing, a via is automatically added. You can also change the track size and miter (corner diameter) as needed.

Newer versions of EAGLE also have a "follow-me router" mode which is a hybrid between manual and automatic routing.

Tracks in EAGLE are shown in a transparent manner so you can easily see bottom layer tracks, even if they are covered by top layer tracks or polygon fills.

Polygon fills

As well as connecting components with tracks, you can use polygon fills. You draw an outline, consisting of a series of line segments and then an area of copper is created inside, joining together any contained pads. This can make better use of the available area on the PCB, allowing for higher currents than with a simple track.

Actually, polygon fills are usually assigned a net and in this case they will only connect pads and tracks assigned to that net. Other pads and tracks within the drawn outline are automatically routed around, with a clearance as defined in the design rules

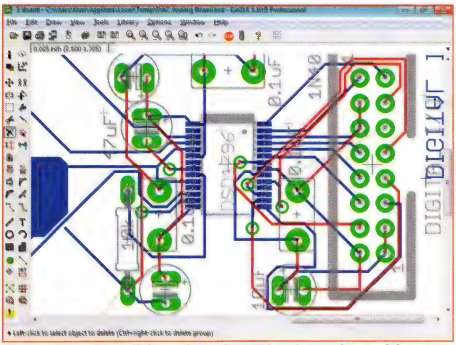

Fig.5: we "ripped up" all the tracks on the PCB by selecting them and doing a group operation, then ran the auto-router. It managed to route most of the tracks. We could route the rest manually or else change the auto-router parameters to make it try harder and repeat the process.

(see below). This makes them a very convenient way to connect a number of nearby pads.

Polygons can be hidden using the "ripup" command (normally used to delete track sections) and then reinstated using the "ratsnest" command. This is convenient since sometimes it's easier to work on the board without the polygon fills in place. The "ratsnest" command also re-draws the lines which show which pads are yet to be connected together. It's called a "rat's nest" because it can look rather messy! It can be turned off if these lines get in the way (via the View menu).

Design rule checking

With any PCB layout, you need to be sure that the parts and tracks are arranged in such a way to minimise manufacturing faults or construction problems, ie, components on the same side do not overlap, all nets are properly connected with no short circuits and all manufacturing rules are observed. This includes minimum hole sizes and separation, minimum track and pad clearances, minimum track widths and so on.

EAGLE's default rules are quite sensible but you may need to customise them to suit your PCB manufacturer. The rules include:

- Which layers can be connected by vias (buried, through and blind);
- Wire, pad, via and SMD pad clearances (individually settable);
- PCB edge clearances for tracks and holes;
- Minimum track width, hole size, blind via size and ratio;
- Via pad to hole ratio ("restring");
- Supply layer connection restrictions;
- Solder mask and solder paste mask clearances; and
- Part grid alignment, track angles and miscellaneous.

These are all easy to configure. Once you have set these you can run a Design Rule Check (DRC) at any time. Any rule violations are listed in a box and if one is selected, the offending location is shown and highlighted (see Fig.3). You can then elect to fix it, ignore it or approve it. Approved errors are moved to a separate list and are not shown unless you explicitly select them.

One nice aspect of EAGLE's DRC feature is that the violations are easily visible but they do not add a lot of visual clutter, so you can continue layout and then come back to fix violations later.

Manufacturing

Once the layout is complete and error-free, the board can be made. The CAM (Computer Aided Manufacturing) processor creates the necessary files. It supports many different output formats and is very flexible.

The most commonly used output formats are Gerber, Excellon and Postscript. In each case, you need to produce multiple files: the copper pattern (more than one for multi-layer boards), the solder mask pattern(s), silkscreen overlay(s), drilling data and so on.

Each component footprint consists of pads or polygons which exist on a particular "layer" (this is also true of board elements like tracks, vias and free text). There are about 50 possible layers, including those for top/bottom copper, pads, vias, board dimensions, component outlines, names, values and so on. In the CAM processor, you select which layers go into which output files.

For example, the silkscreen layer usually combines the component outlines, names and values for one side of the board, as well as the "documentation" layer (text, etc).

Each file produced normally has a different extension. Usually the copper, solder mask and silkscreen layers are saved in Gerber format while the drill data (positions and sizes) can be either Gerber or Excellon. Just about any PCB manufacturer will accept these files. Alternatively, you can output to Postscript files, print them and etch the board yourself.

The CAM processor configuration can be saved to a preset ("job") and several are provided by default, which you can customise if necessary. It's then just a matter of loading the "job" and clicking the "Process Job" button to produce the correct set of output files for manufacture.

Conclusion

CadSoft EAGLE is an affordable, fast, easy-to-use circuit editor and PCB layout package. It doesn't have a huge number of features but it certainly includes everything you need for regular PCB layout tasks. We found it pleasant and intuitive to use.

Its interface is very similar regardless of the operating system used (Windows, Mac OSX and Linux) and all files are fully compatible.

Probably its greatest strength is in the ability to start with the free version and then upgrade later when you need more capabilities. You can "try before you buy" so why not give it a try! SC

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Last month we introduced our new Hifi Headphone Amplifier which features very low distortion and noise. It can even drive efficient 8-ohm speakers. This month, we show you how to build and test it.

By NICHOLAS VINEN

Hifi Stereo Headphone Amplifier, Pt.2

THE ASSEMBLY of the Hifi Stereo Headphone Amplifier is straightforward, with all the parts mounted on a single PCB coded 01309111 and measuring 198 x 98mm. Apart from the PCB, there is no other wiring.

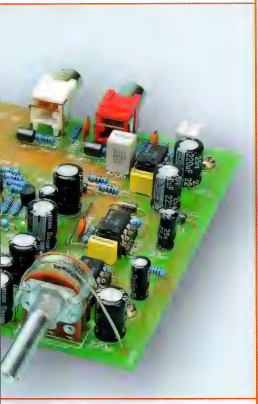
Fig.9 shows the parts layout on the board. Before starting assembly, it's a good idea to test-fit the larger components (eg, the jack socket, heatsinks, RCA sockets and so on) to check that their mounting holes are large enough.

That done, begin by installing the 10 wire links using 0.7mm-diameter tinned copper wire or component pigtail off-cuts (don't forget the one near CON3). Once those are in, install the resistors, noting that two (both 100Ω just below the RCA sockets) have ferrite beads on their leads. Check each resistor with a DMM set to Ohms mode before soldering it into place.

Follow with the 14 1N4004 diodes, taking care to ensure they are all correctly orientated. In each case, the stripe faces to the left or the bottom of the board. The four BAT42/BAT85 small-signal Schottky diodes (D15-D18) near IC1 (upper-left) can then go in. Their orientations vary so take care.

If you are using sockets for IC1-IC3, install them now with the notches to the right as shown. Alternatively, you can solder the ICs direct to the board with the same orientation.

The MKT and ceramic capacitors are next on the list, followed by the 20 small-signal transistors. There are four different types so be sure to install the correct type at each location. Use a small pair of needle-nose pliers to crank the transistors leads so that they mate with the board holes and take care to ensure that each transistor is correctly orientated.



The two 500Ω trimpots and the fuse-holder clips can now go in. Check that the small fuse clip retention tabs are towards the outside before soldering the fuse clips, otherwise you won't be able to fit the fuse later on.

That done, fit PCB pins at test points TP1-TP4 plus another two to support the tinplate shield between inductors L3 & L4. Once they're in, fit the electrolytic capacitors but leave the two 2200µF filter capacitors out for the time being.

Installing the LED

Before installing the 3mm blue LED, you need to bend its leads down by 90° exactly 4mm from the rear of the lens. Be sure to bend the leads in the right direction though, so that the longer anode lead goes through the hole marked "A" on the layout diagram.

Once the leads have been bent down, solder the LED in place with the horizontal section of its leads 6.5mm above the PCB surface (a cardboard spacer can be used to set the height). This ensures that it will later line up with its front panel hole and will be in line with the centre shaft of the adjacent switch (S1).

Winding the inductors

The two air-core inductors (L3 & L4) are wound on small plastic bobbins. It is much easier to wind them if you make a winding jig, as shown in the adjacent panel.

To wind the first coil, first secure the bobbin to the jig with one of its slots aligned with the hole in the end cheek. That done, feed about 20mm of a 1m-length of 0.8mm-diameter enamelled copper wire through the

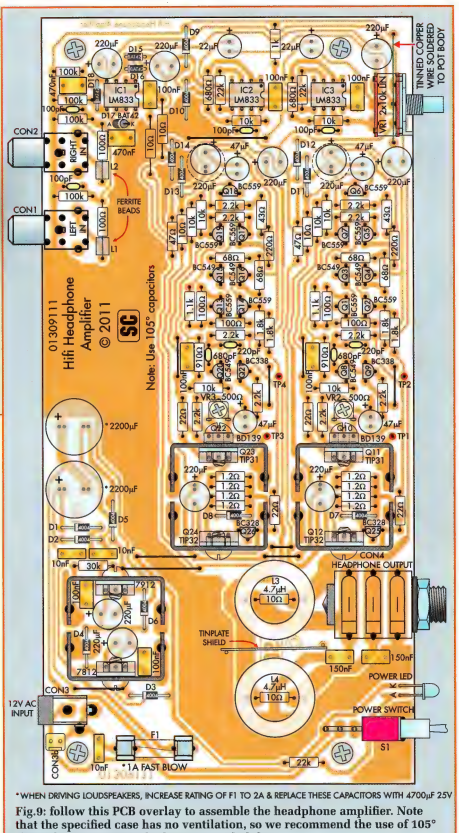
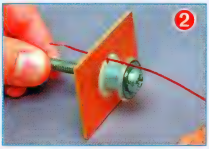


Fig.9: follow this PCB overlay to assemble the headphone amplifier. Note that the specified case has no ventilation, so we recommend the use of 105° electrolytic capacitors for long-term reliability.

A Winding Jig For The Inductors



The winding jig consists of an M5 x 70mm bolt, two M5 nuts, an M5 flat washer, a piece of scrap PC board material (40 x 50mm approx.) and a scrap piece of timber (140 x 45 x 20mm approx.) for the handle.

The flat washer goes against the head of the bolt, after which a collar is fitted over the bolt to take the bobbin. This collar should have a width that's slightly less than the width of the bobbin and can be wound on using insulation tape. Wind on sufficient tape so that the bobbin fits snugly over this collar.

Next, drill a 5mm hole through the centre of the scrap PC board material, followed by a 1.5mm exit hole about 8mm away that will align with one of the slots in the bobbin. The bobbin is then slipped over the collar, after which the PC board "end cheek" is slipped over the bolt. Align the bobbin so that one of its slots lines up with the exit hole in the end cheek, then install the first nut. The handle is then fitted by drilling a 5mm hole through one end, then slipping it over the bolt and installing the second nut.

hole, then carefully wind on 20.5 turns before bending the end down so that it passes through the opposite slot in the bobbin. Trim the "finish" end of the wire to 20mm (to match the start end), then secure the winding with a layer of insulation tape and remove the bobbin from the winding jig.

A 10mm-length of 25mm-diameter heatshrink tubing is used to finally secure the winding. Slip it over the outside and gently heat it to shrink it down (ie, be careful to not melt the bobbin).

The second coil is wound in exactly the same manner. Once it's finished, scrape the enamel off the leads on both inductors and tin them before fitting them to the PCB.

Completing the PCB assembly

The PCB can now be completed by fitting the remaining large items, starting with the SPDT power switch. Make sure it sits flat against the PCB and is at right-angles to it before soldering its pins. The power socket can then go in, followed by the RCA sockets (CON1 & CON2).

Use a red RCA socket for CON1 (right) and a white RCA socket for CON2 (left). Be sure to push the sockets all the way down onto the board, so that their plastic locating tabs go into the corresponding holes, before soldering their pins.

The tinplate shield between the two inductors can now be installed. This shield measures 35 x 15mm and can be cut from the lid of a large Milo tin using tin snips. File the edges smooth after cutting, then temporarily position it between the two PC pins and mark their locations.

That done, hold the shield in an alligator clip stand and melt some solder onto either side at the marked locations. It may take 10 seconds or more to heat it enough for the solder to adhere.

Finally, melt some solder onto the tops of the two PC pins before fitting the shield in position and remelting the solder to secure it.

Preparing the potentiometer

The 16mm dual-gang potentiometer (VR1) may need to be modified before installing it on the board. Take a look at the pot – the flat section of the shaft must extend all the way back to the threaded mounting bush. If not, this flat section must be extended.

To do this, lightly clamp the tip of the shaft in a vice with the flat section facing upwards and use a file to extend this section back to the threaded bush. Once that's done, cut the shaft to a length of 7mm and file off any burrs.

It's also necessary to remove a small area of the metal passivation layer on the top of the pot body (use a file), after which the pot can be soldered to the PCB.

The metal body of the pot must be earthed. This is done by first soldering an 80mm-length of tinned copper wire to an adjacent pad immediately below the pot (ie, between it and the adjacent 220µF capacitor). This wire is then looped across the top of the pot, pulled down and soldered to the top-right pad on the PCB and to the pot's body (ie, where you exposed the bare metal earlier).

Mounting the heatsinks

The two regulators and six power transistors are mounted on six large flag heatsinks. These have two posts which pass down through the PCB for support.

Start by loosely fitting the 7812 and 7912 regulators to their heatsinks as shown in Fig.10(A). Note that, in each case, the regulator's metal tab must be isolated from its heatsink using an insulating bush and silicone washer.

That done, fit the 7812 regulator assembly through the lower set of holes just above CON3 and D3 (see Fig.9). If the heatsink has "solderable" pins, flip the board over and solder one, then double-check that it is sitting perfectly flush with the board before soldering the other. Since you have to heat up quite a bit of metal, it could take 15 seconds or more before the solder adheres to the post.

Alternatively, if the heatsink doesn't have "solderable" pins, use pliers to bend the tabs outwards far enough so that it is secured to the board.

Having secured the heatsink, check that the insulating washer is properly

The PCB assembly is a neat fit inside the recommended Altronics case. Note how the body of the volume control pot (top, left) is earthed using a length of tinned copper wire. This wire is looped across the top of the pot's body and is terminated in solder pads on either side (see Fig.9).

aligned with the regulator and tighten the mounting screw. The regulator's leads can then be soldered. Repeat this procedure for the 7912 regulator.

The two TIP32 power transistors (Q12 & Q24) are mounted in identical fashion to the regulators. By contrast, the heatsinks for the two TIP31 power transistors (Q11 & Q23) have the BD139 V_{BE} multiplier transistors mounted on the other side. Fig.10(B) shows the mounting arrangement. Be sure to insulate all the transistors from the heatsinks using silicone washers and insulating bushes as necessary.

You can now fit the 6.35mm jack socket. The type we used does not sit right down on the board due to the shape of its pins but rather sits above the board by about 4mm. If your jack socket does not have "necked" pins, you will either need to extend them or its front panel hole will have to be lowered by 4mm when you drill it later.

Finally, fit the two 2200µF capacitors. As mentioned in Pt.1, if you use 4700µF 25V capacitors (ie, for more output power), they must be no taller than 30mm and no more than 16mm in diameter, otherwise the assembly will not fit into the specified case.

Test & adjustment

The assembled board can now be tested. First, turn both trimpots and the volume control potentiometer fully anti-clockwise, then clip a multimeter set it to its highest AC amps mode across the fuseholder (without the fuse in place). The easiest method is to use alligator clip leads.

Next, connect the 12VAC plugpack and apply power. You should get a reading of 120mA ±20mA (no op amps installed) or 160mA ±20mA (op amps installed). If the current does not fall inside this range after about a second, switch off the plugpack at the wall and check the board for faults such as solder bridges between pads and tracks.

Assuming it's OK, switch off, install the op amps if they aren't already on the board and check the current consumption again (ie, it should be 160mA ±20mA).

Now turn the power off, install the fuse and connect a multimeter set to volts/millivolts mode between TP1 & TP2. That done, switch on and check the reading – it should be very close to 0mV.

Now slowly adjust VR2 clockwise. At first nothing will happen but eventually the reading should start to rise. Adjust it for a reading of 28.5mV. This sets the quiescent current in the left channel to 47.5mA. Note that this reading may slowly rise as the transistors warm up so leave it on for a few minutes and then re-adjust it.

Once that's done, switch off and connect the multimeter between TP3 & TP4. VR3 can now be adjusted for a reading of 28.5mV, to set the quiescent current in the right channel.

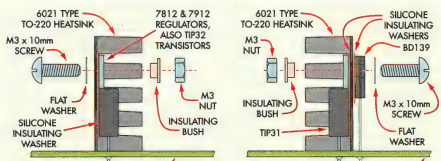


Fig.10: follow this diagram to install the regulators and output transistors on their heatsinks. Make sure that the metal tabs of all devices are isolated from the heatsinks using insulating washers and bushes as required. Note that the heatsinks should be either soldered or clamped to the PCB before soldering the device leads, to avoid stress fractures.

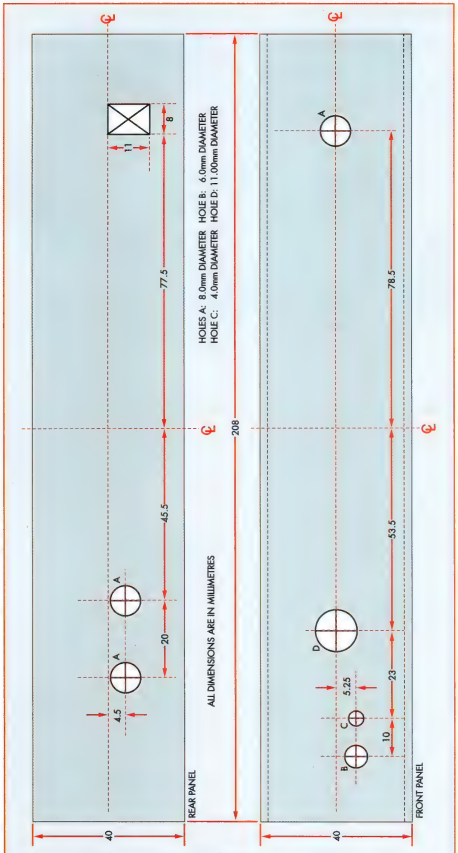


Fig.11: the drilling templates for the front & rear panels. Start each hole with a small pilot drill and then enlarge it using larger drills and a tapered reamer as necessary. The rectangular cut-out is made by drilling and reaming a 6mm hole in the centre and then shaping it using a flat needle file. Be sure to correctly position the templates before drilling the holes.

The final test is to connect a signal source and headphones and slowly turn the volume up. If you hear clear, undistorted sound from both channels then the board is working properly.

Provided the quiescent current is set correctly for both channels, the idle current will be about 340mA (AC RMS), giving a power consumption of about 4W. With headphones, this does not usually increase but it may be higher when driving loudspeakers, depending on the volume level and speaker efficiency.

Drilling the case

A half-size 1-unit steel case (Altronics H4995) is used to house the PCB assembly. Other cases are also suitable provided the PCB fits, although you will probably have to chassis-mount the RCA input sockets and power connector. If chassis-mounting the RCA connectors, it will be necessary to use shielded cable to connect them to the PCB.

The drilling templates for the Altronics case are shown in Fig.11. Disassemble the case entirely first, by removing all the screws. It separates into three pieces: the aluminium base (and rear panel), the front panel and the steel lid. Remove the feet as well and place them and the screws into the provided snap-lock plastic bag for safe-keeping.

Next, download and print out the drilling templates and attach them to the front and rear panels. Use a punch to mark the centre of each hole. Alternatively, you can start the holes with a small bit (say 1mm) and a hand-drill. Either way, drill pilot holes (eg, 1.5mm) in each location before enlarging them to size using larger drills and a tapered reamer.

The hole which must be the most accurately placed is that for the power switch. The LED leads can be bent to compensate for any inaccuracy in its mounting hole position and those for the output socket and volume control can just be made slightly oversize. Note that the hole for the power LED is drilled to 4mm to suit a plastic LED clip.

The rectangular cut-out for the power socket is made by first drilling and reaming a 6mm hole in the centre before carefully enlarging it to a rectangular shape with a flat needle file.

Once the drilling has been completed, download the front and rear-

Another view inside the completed unit. Make sure that the screws used to secure the lid clear the underside of the PCB – see text. Note that the PCB shown here is a prototype and differs slightly from the final version shown in Fig.9.

TABLE 1

Sound Pressure Level	Maximum Recommended Exposure (per 24 hours)
88dBA(SPL)	4 hours
91dBA(SPL)	2 hours
94dBA(SPL)	1 hour
97dBA(SPL)	30 minutes
100dBA(SPL)	15 minutes
103dBA(SPL)	7 minutes
106dBA(SPL)	3 minutes
109dBA(SPL)	1 minute
112dBA(SPL)	30 seconds
115dBA(SPL)	15 seconds

panel labels (in PDF format) from the SILICON CHIP website and print them out. These labels can then be trimmed and laminated before affixing them to the panels using double-sided adhesive tape. The holes are cut out using a sharp hobby knife.

Mounting the board

The PCB assembly is mounted on the same machine screws that secure the rubber feet to the case. Remove the supplied short machine screws from the feet and insert M3 x 15mm screws instead, then re-attach them to the base. Once they're all in place, slip three M3 flat washers over each screw thread, then fit a Nylon nut/washer combination over the top, with the larger "washer" section at the top (note: if you can't get these, use separate Nylon nuts and washers instead, with the washers on top).

Next, undo the two rear two screws until only a tiny bit of thread is sticking out above the Nylon washers (say 1mm), then introduce the board by pushing the RCA sockets and DC input connector through their respective holes. It's then just a matter of dropping the front of the board down onto the screw threads, after which you can re-tighten the rear mounting screws.

The lid is held in place by two screws on each side and these should just clear the underside of the PCB. Temporarily fit these screws (ie, without the lid) to check this. If any of screws do foul the PCB you will need to remove it and add more M3 flat washers under the Nylon nuts.

Once it's correct, fit M3 nuts to all four screws to secure the PCB in place, then remove the nuts and washers from the jack socket and volume control pot. The front panel can then be attached by slipping it into place and installing the two screws at the bottom. Once it's secured, push the plastic LED clip into place and push the LED into the clip from the back.

The assembly can now be completed by reinstalling the washers and nuts for the jack socket and volume control, attaching the knob and fitting the lid.

Using it

Finally, here are a couple of tips for using the headphone amplifier.

First, always turn the volume knob right down before donning the headphones and then turn it up to a comfortable level. If you don't do that, you risk hearing damage. This particularly applies if somebody has left the volume control turned fully up or if the signal source is much louder than it was the last time you used the headphone amplifier.

Similarly, do not listen at high volume levels for long periods. This is especially critical with a headphone amplifier as it's easy to expose yourself to damaging sound pressure levels without too much apparent discomfort (and without anyone else noticing).

Table 1 shows the recommended maximum exposure periods for various sound pressure levels (SPLs) ranging from 88-115dBA. In short, don't make a habit of listening to loud music via headphones. SC

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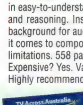

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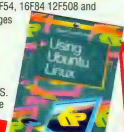

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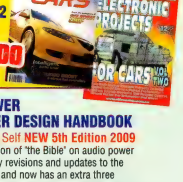

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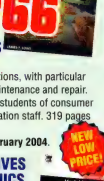

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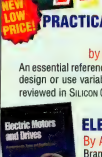

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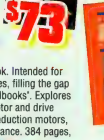

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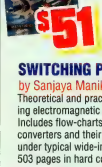

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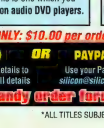

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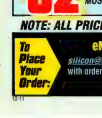

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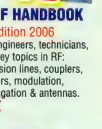

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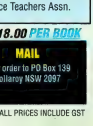

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Vintage Radio

By Maurie Findlay, MIE Aust, VK2PW

A look at the Radiola Model 573-MA Receiver

Manufactured in the early 1950s, the AWA model 573-MA is a 5-valve superhet, designed for the 540-1600kHz broadcast band. It features an attractive plastic case and a large straight line dial with stations for all Australian states clearly marked.

BEFORE THE INTRODUCTION of television to Australia in 1956, radio and gramophone records were a prime source of entertainment. Typically, a household would have a radio and maybe a gramophone in the lounge room and the family would gather in the evening to listen to the radio or records.

With the war some years away and economic conditions improving, the dream of having several radios in the household became a reality for many. In addition to mains receivers, there were battery-powered portable sets but these were expensive to run and a good many did not work all that well.

The Radiola Model 573-MA operates from mains power and requires only 40W. Furthermore, this set has a very effective inbuilt antenna and can be shifted around to wherever there is a power outlet without having to install an antenna wire. This could be the kitchen, the bedroom or the outside workshop.

The set was manufactured by Amalgamated Wireless (Australasia) Ltd and the valves by their associated company, AWV. The valves were new to Australian technicians at the time and were much smaller than their predecessors which had octal and other plastic bases. They were of all-glass construction, with seven pins at one end providing all the connections.

Circuit details

Fig.1 shows the circuit diagram of the set. It's a superheterodyne design with five valves: a frequency changer (V1), an intermediate frequency (IF) amplifier (V2), a detector/audio amplifier (V3), an audio power amplifier (V4) and a rectifier (V5). It's pretty much a standard line-up for medium-wave receivers designed at the time.

There are a few special features about the design. These include a ferrite rod antenna, a neutralising circuit for the IF amplifier, simple rather than delayed AGC (automatic gain control) and a negative feedback circuit with associated treble cut and boost.

The frequency changer is a 6BE6 which has a simplified geometry in order to fit all the connections within the 7-pin limitation (the screen grid serves as the plate for the local oscillator). This valve actually provides more conversion gain when used on the broadcast band than some earlier octal based types.

Intermediate frequency (IF) amplification at 455kHz is achieved using a 6BA6 which is a variable-mu pentode with AGC applied to the grid. It also has the potential for higher gain than earlier octal-based valve types. Again, looking at the circuit, early versions of the set used a cathode bias resistor without a bypass capacitor in order to reduce the gain. Later models included the bypass capacitor as well as a neutralising circuit.

The detector/amplifier stage (V3) is a 6AV6 which has two diodes and a triode in the one envelope. One diode detects the 455kHz intermediate frequency signal and at the same time provides the AGC voltage. The other diode is not used and is simply connected to earth. The triode section

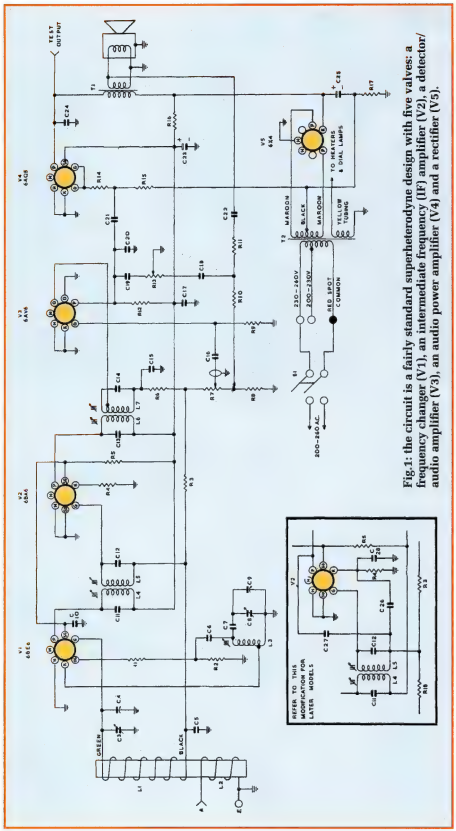

Fig.1: the circuit is a fairly standard superheterodyne design with five valves: a frequency changer (V1), an intermediate frequency (IF) amplifier (V2), a detector/audio amplifier (V3), an audio power amplifier (V4) and a rectifier (V5).

provides substantial audio gain and is a commonly-used circuit. The grid return resistor (R9) is 10MΩ while its plate load resistor (R12) is 0.22MΩ.

The the 6AQ5 valve (V4) is the familiar beam-tetrode in miniature form. It provides gain and the audio power to drive the loudspeaker. R14, a 47kΩ resistor in the grid circuit, is there as a precaution against parasitic oscilla-

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Despite the set's age (about 60 years), the chassis is still in good condition. It was one of the first Australian-made sets to use the new 7-pin "miniature" valves (also Australian-made).

tions at frequencies outside the audio range. The valve must be operated in a linear mode for low distortion and negative bias is provided via R17, a 150Ω resistor in the supply line.

V5, a type 6X4, rectifies the AC output of the transformer to provide 240V DC for the plate of the 6AQ5. It also provides, via dropping resistor R16 (5kΩ), 165V DC for the screen of the 6AQ5 and the plates of the other valves.

A special feature of the 6X4 is that it has insulation between the heater and cathode elements, designed to withstand the high-tension (HT) voltage. The heater can be operated from the same supply as the heaters for the other valves, ie, with one end connected to earth.

TABLE 1: DC RESISTANCE OF WINDINGS

Ferrite Aerial Assembly:	
Primary (L1)	<1Ω
Secondary (L2)	1Ω
Oscillator Coil (L3)	3.5Ω
IF Transformer Windings	15Ω
Power Transformer (T2):	
Primary	50Ω
Secondary	350Ω
Loudspeaker Transformer (T1):	
Primary	525Ω or 430Ω
Secondary	<1Ω

The above readings were taken on a standard chassis but it should not be assumed that a component is faulty if a slightly different reading is obtained.

Restoration

The old Radiola Model 573-MA receiver pictured here originally came to me complete in its plastic case and with a copy of the AWA service data. This included the specifications, circuit diagram, alignment procedure, a table showing the resistance of the various coils and transformers, and a table of the valve socket voltages.

Bearing in mind that the set was nearly 60 years old and might have had all sorts of faults, there was no question of immediately plugging it into 230VAC and switching it on.

Nothing in the service data described how to get the chassis out of the plastic case but after observation and some thought, I began by removing the knobs by pulling them straight out from the front. The back of the case proved more elusive. It is held by two screws, recessed at the top and another two screws towards the back and underneath the case. In the process of removing the back, the brackets holding the back broke away from the case. They were later repaired using epoxy cement and 3mm screws, just to make sure.

At this stage, the chassis was still firmly attached inside the front of the case by another two screws underneath the case. These were also removed and the metal chassis was then slid out of the case to reveal a broken dial cord. Fortunately, the service data includes a diagram which shows how to string the cord and attach the pointer.

A thorough visual check above and below the chassis revealed nothing out of order, apart from a generous layer of dust. As far as reasonably possible, this was carefully removed with a soft brush

Next, using a digital multimeter, the resistance of the primary winding of the power transformer was measured (see the manufacturer's table "DC Resistance Of Windings" reproduced here). This was within specification. The next measurement, the resistance between the primary and the chassis, was of the utmost importance. It was greater than 10MΩ which is very good.

In addition, the resistance of the primary of the loudspeaker transformer winding was measured to ensure the safety of the 6AQ5. If this winding goes open circuit, the screen grid of the valve will draw excessive current.

Next, the resistance between the

high-tension line and the metal chassis was measured. It was more than 0.5MΩ which suggested that the electrolytic capacitors were possibly in reasonable condition and that it may be safe to switch on the mains power.

The 573-MA was originally fitted with a 3-pin plug and a 2-wire figure-8 power flex. This is simply not satisfactory for safety these days. So, before switching on, a 3-core flex was fitted and the earth wire securely attached to the metal chassis. This was done by crimping the earth wire to an eyelet lug which was then secured using a machine screw, nut and shakeproof washer. Do not rely on a solder joint to the chassis.

In addition, a cable clamp was fitted to secure the mains flex in place, along with a grommet where the cable exits the metal chassis. This ensures that the outer insulation of the mains cord is not damaged by external strain.

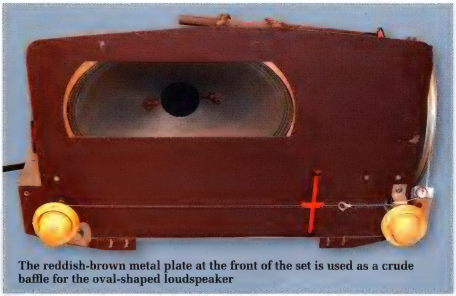
With the above precautions, a fault in the primary power circuit will either cause the earth leakage circuit breaker at the switchboard to disconnect the power or will cause the fuse to blow, thus ensuring safety.

Surprise, surprise. With the power applied, the set worked perfectly, receiving all local and one or two distance stations in daylight! Not a single component was changed and not a single adjustment moved. What a contrast with the recent experience with the Hotpoint J35DE receiver (SILICON CHIP, July-September 2011)

The service data states that "all adjusting screws are sealed". Except for the aerial trimmer (C3, 27pF), it means exactly what it says.

Performance

I was left no alternative but to resort to the "big guns" in the form of laboratory instruments to get some quantitative idea of performance. The signal gathering performance of the ferrite rod antenna is not easy to measure, It's basically a function of the volume of the rod and the "Q" factor.



The reddish-brown metal plate at the front of the set is used as a crude baffle for the oval-shaped loudspeaker

It is possible to arrange a known field strength using a signal generator and an inductor placed at a specified distance from the ferrite rod. However, this is fairly cumbersome and is hardly justified when weak station performance has been demonstrated.

The manufacturer's alignment table states "a coil comprising three turns of 16-gauge DCC wire and about 12 inches (30cm) in diameter should be connected between the terminals of the test instrument, placed concentric with the rod aerial and distant not less than 1 foot from it." No expected sensitivity figures or settings of the AWA modulated oscillator are given.

My aim was to measure the bandwidth of the intermediate frequency (IF) channel and the overall audio response of the set. To do this, a laboratory RF signal generator and an audio signal generator were pressed into service.

Unfortunately, the AWA arrangement would make it very difficult to maintain constant coupling between the RF generator and the ferrite antenna. To circumvent this, I simply wound three turns of hook-up wire around the end of the ferrite rod. The relative signal strength was measured using a digital multimeter connected between the junction of R3 and R18 and earth. Obviously, the circuit was detuned but this does not make any difference to the intermediate and audio response.

For most local stations, without the signal generator connected, the meter read about -4V. Bear in mind that the ferrite rod antenna is directional and has least signal gathering capacity when pointed end-on in the direction of the station. However, the reserve of sensitivity is considerable and when turning the chassis around while tuned to local stations, the minimum pick-up orientation is usually noticed only by a slight increase in background noise.

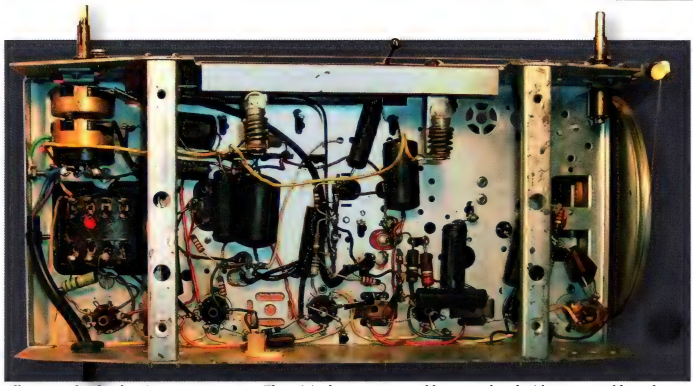
Why simple AGC?

This brings me back to an interesting point about the circuit: why did the designer choose a simple automatic gain control system when the usual delayed AGC system would have involved only a couple of inexpensive components?

I believe that the answer is related to the ferrite rod antenna and its proximity to the power transformer. When the set is tuned away from a station, hum

TABLE 2: SOCKET VOLTAGES

Valves	Cathode To Chassis Volts	Screen Grid To Chassis Volts	Anode To Chassis Volts	Anode Current mA	Heater Volts
6BE6 Converter	–	85	165	2	6.3
6BA6 IF Amplifier	1.5	85	165	4.5	6.3
6AV6 Detector/Amplifier	–	–	80	1	6.3
6AQ5 Output	–	165	240	20	6.3
6X4 Rectifier	250	–	235/235 AC RMS	–	6.3



All parts under the chassis are easy to access. The original 2-core power cable was replaced with a 3-core cable so that the chassis could be earthed.

can be heard in the speaker. But tune to even a very weak station and the hum immediately stops. Had delayed AGC been incorporated, hum would be present on weak stations.

Another design feature of the set, unusual for the 1950s, is the negative feedback and tone control system. The feedback is taken from the secondary winding of the output transformer, via C22, R11 and R10 in series and developed across R8 (100Ω) at the lower end of the volume control (R7). In addition, the junction of R10 and R11 is connected via C18 to one end of the tone control potentiometer R13 (100kΩ). Its moving arm (wiper) is earthed, while the other end is connected to the plate of V3 via C19 (0.01μF).

When the set is first switched on, C19 bypasses the plate of the 6AV6, resulting in severe treble cut. However, with R13 fully rotated, C18 (0.25μF) is connected to ground, reducing the negative feedback at higher audio frequencies and hence providing treble boost. Very clever!

The tone control is the small knob at the front left of the set, while the volume control is the larger concentric knob behind it. The on/off switch is operated by the tone control. When you first switch on, you make the decision: leave it with a "mellow" tone or rotate the knob fully and be able to understand speech!

Audio response

The measured centre frequency of the IF amplifier is very close to 455kHz and the -6dB bandwidth is 7kHz. The overall audio response with the tone control fully clockwise is only -2dB down at 3kHz. Although this is poor compared with modern digital or FM sets, it still makes for pleasant listening. The response curves are reproduced in Fig.3.

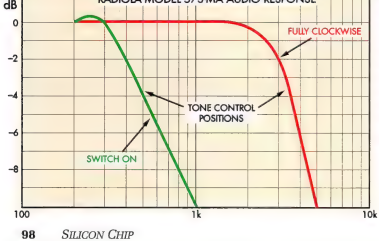


Fig.3: this graph shows the audio response of the set at switch-on and with the tone control turned fully clockwise (the on/off switch is integrated with the tone control).

The audio power output is a little less than 1W RMS at the point of clipping when fed into a 3-ohm resistive load. I double checked this and also checked the emission of the 6AQ5, as the service data sheet claims 3W undistorted. Even so, the 1W of audio is more than enough for the sensitive permanent-magnet speaker which is mounted on a metal plate. This certainly does not provide a good baffle for the lower audio tones.

So, 60 years later, are there any improvements to be made to the circuitry? Answer: none that would make a really worthwhile improvement. However, over-coupling of the 1st IF transformer and damping of the primary of the second IF (see SILICON CHIP, September 2011) would extend the audio response.

In addition, the current drain and hence heat dissipation could be reduced by slightly increasing the value of the back bias resistor (R17, 150Ω).

Finally, capacitors C17 (0.1μF), C23 (25μF electrolytic) and C25 (25μF electrolytic) were replaced in the interests of long-term reliability. SC

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MPPT solar charger needs adjustments

I recently built your MPPT Solar Charger (SILICON CHIP, February 2011) and I have noticed that at the start of each day it goes straight to float charge. This is even if I have used substantial battery power the night before. In order to make it do the full charge regime I have to switch open the connection between battery and controller to fully de-energise it for 30 seconds so that it starts afresh and bulk charges when the Sun comes up.

I have also noticed that if I switch on a big load during the day, so much so that the voltage drops to below 12.45V (even down to 12.0V for a few minutes), it still will not go to a bulk charge. This is not right. I am using two 40W amorphous panels in parallel and a 12V 110Ah SLA battery.

Is there any updated software yet to fix this problem? (B. H., via email).

● We have not upgraded the software since there are no problems that we know of. Bulk charge occurs if the battery drops below 12.45V. It is how the battery voltage is monitored and the set-up adjustments that affect this reading.

Failure to start the bulk charge after a night-time period could just mean that the VR3 adjustment needs altering. This adjustment sets the voltage that is detected by microcontroller IC1 (ie, it sets a divided down value of the battery voltage).

If VR3 is set to give a higher voltage than it should, IC1 will not detect the 12.45V low battery voltage correctly and bulk charge will not begin. Alternatively, the 5V supply might not be exact as set by VR1.

Check the set-up as detailed on page 48 of the February 2011 issue for VR1 and VR3. If the adjustments are correct, try setting VR3 so that the TP1 voltage is a little lower than the calculated voltage of 0.3125 x the measured battery voltage.

In addition, the compensation adjustment at VR2 for battery temperature can affect the charging voltage.

Lightning trigger for digital cameras

I read with interest the project on the Lightning Detector in the July 2011 issue by John Clarke. I will be keen to purchase a kit and see how this works.

Has SILICON CHIP ever had a Lightning Trigger project for digital cameras? I have checked the archive list and there appears to be no project of this nature listed. I would suspect that this would make an interesting project and would be extremely popular. I have seen results from triggers that have been purchased overseas showing stunning lightning shots.

Is this a project that SILICON CHIP might consider in the future for the popular Canon, Nikon and Pentax cameras? (R. H., Woomera, SA).

● That's an interesting question. Given that a lightning detector would have to operate the "shutter" on a digital camera, how could any digital camera be fast enough to take a picture of a lightning flash which lasts about 200 milliseconds? We understand that most lightning photos were taken by cameras with the shutter open. Having said that, it would be simple enough to add a shutter release Mosfet to the Lightning Detector.

Incidentally, there is no kit for this project but SILICON CHIP can supply the PCB for $25 plus $10 for postage and packing.

Digital tacho faulty but not on YouTube!

Your circuit for the Digital Tachometer (SILICON CHIP, April 2000) has a problem and it cannot be functional without alteration. I have seen videos of this tachometer on YouTube. I was amazed at how this circuit is working fine over there and not with me.

It has lethal circuit mistake that could have fried this circuit. I assumed people at YouTube must have done some alteration to the existing diagram to make it functional.

The LM358 is driving the RB0/INT pin of the PIC16F84A at 12V! This will kill the microcontroller and fry the 7805 regulator. My unit has burnt out the 7805 regulator and LM358 op amp and the PIC16F84A is now faulty even though the programmer is able to burn it, erase and reprogram it. It is not even able to light up an LED properly. (U. F., Karachi, Pakistan).

● There is nothing incorrectly de-

False Readings From Digital Tachometer

I am having some problems getting my Digital Tachometer (SILICON CHIP, April 2000) to work correctly. The bargraph and digital display is operating and the mode functions all work. It is set up for a 4-cylinder 4-stroke engine and is attached to the ignition coil.

My problem is that when it is wired to the car the RPM readout is much too high and is very unstable. The tacho shows 1600-2200 RPM when the car's true revs are actually 800 RPM (idling).

As the revs go higher it gets worse, showing 6400-7300 RPM when the true figure is 2400 RPM.

I am unsure what is causing the problem. Do I need different resistors? Have I put something in the wrong place? (T. D., via email).

● The tachometer is false-reading due to ringing from the ignition coil signal. You can fix this by increasing the 0.056µF (56nF) capacitor at the ignition coil input of the tachometer, following the 22kΩ 1W resistor. The capacitor may need to be increased to 100nF or 150nF to prevent the false triggering.

Modifying A Speed Controller For Low-Voltage Motors

I am investigating the use of the 20A 12/24V DC Motor Speed Controller (SILICON CHIP, June 2011) with 4-6V Faulhaber motors. These motors can provide sufficient torque for one of my applications at steady DC voltages of around 0.5V, with currents of less than 0.5A.

Would it be safe to use the unit for my Faulhaber motors or alternatively, can it be simply modified to be safe? I should mention that the Faulhaber motors use ironless rotors to reduce inertia. (A. T., via email).

● The minimum voltage that the circuit can run at correctly is 7V, although it may run at lower voltages depending on the particular TL494 (IC1). In this case, the LM2940CT-12 regulator should be omitted and a link connected in its place (between the IN and OUT pads on the PCB).

The output from the controller to drive the motor would then range from 7V to 0V. The lower voltage settings would produce 7V pulses to the motor. This means that at 3.5V average there will be a 50% duty pulse at 7V peak. Whether this is suitable for the motor we are not sure but the windings will run hotter due to the higher pulse current.

It may be wise to change the 1kΩ resistor at the lower end of the speed pot to a larger value that restricts the pulse width to rather less than 100% when the pot is adjusted to full speed. A 4.7kΩ resistor or higher might be suitable.

The Mosfets will be driven into saturation with gate voltages down to 6V, especially at the low currents the motors will be drawing, so there is no need for logic-level Mosfets. In fact, you really only need one Mosfet for your application.

As an alternative to the changes mentioned above, the motor speed controller circuit could be run from 12V as normal but with supply for the motor coming from a lower voltage source such as 1.5V or 3V.

To do this, the on-board 20A fuse would be removed and the 12V supply connected between the +12V and 0V inputs on the controller. The lower voltage supply for the motor would connect between the 0V and the M+ terminals on the controller via an in-line fuse. The motor terminals would connect to the M- and M+ terminals on the controller.

That way the motor is not presented with high-voltage pulses but only the maximum voltage provided by the dedicated motor supply.

signed in the circuit. The output from the LM358 does drive the PIC RB0 input but this is via a 2.2kΩ resistor that limits the current into the PIC input. So with the LM358 powered from 12V, the RB0 input is clamped to just over 5V with the internal clamping diodes across the supply rails within the PIC. This prevents any damage to the PIC chip.

If you are experiencing an overheated 7805 regulator there is probably a short circuit on the PCB. If you have an overheated LM358, check that it is inserted correctly.

We have not experienced any problems with this project and it has been sold as a kit since April 2000. The problems you are experiencing could arise from missing wire links, shorts between component pads with solder bridges, incorrectly orientated components or problems with the 7-way pin headers and plugs.

OBDII interface software problems

I have constructed the OBDII Interface (SILICON CHIP, February 2010) and I'm having trouble getting the software to communicate with the unit. I am using a Netbook running Windows 7 and I have purchased the RS232-to-USB converter cable. The cable software installs without trouble and is assigned to COM4 on the PC. However, the software will not recognise the hardware and the result is about the same when using all three of the suggested software packages.

According to the scope grabs that I have taken, 5V logic data appears on pin 12 of the MAX232 IC (into the processor) and RS232 data does appear on pin 14 of the MAX232 IC . This seems to indicate to me that the hardware is working OK but the software won't recognise the response. The RS232 Rx and Tx LEDs flash as well. The scope grabs were taken when attempting to "start polling" in the OBD v1.5.0 software with the unit powered up but not connected to a vehicle (the symptom is the same when connected to a vehicle).

Note that the baud rate and related settings on COM4 in the software have been confirmed as correct. I tried loading the software and cable onto my desktop PC running Windows XP but the result is the same.

I would appreciate any suggestions you may have. (J. B., Beaumaris, Vic).

● The interface will report an error when not connected to the OBDII port of a vehicle. Most vehicles will require that the engine is running before communication will occur. Also make sure the vehicle is OBDII-compliant.

Possibly the problem is with the OBDII plug. Make sure the pins within the plug are orientated correctly with respect to the plug shell. Some of the OBDII plugs are supplied with the pins oriented 180° from the correct position. This is mentioned in the article where the pin section of the plug is required to be removed and rotated by 180°. Compare the OBDII shell and pins against the supplied drawings.

Speed control wanted for large pedestal fan

I am restoring an old (circa 1950s) "Airspeed" industrial fan or "air circulator". This is a large 3-bladed fan that stood on a tall pedestal and would have moved air on a factory floor or similar. The fan has a single high speed and I am keen to put in some sort of speed control.

I recently bought a Jaycar kit based on your 10A Universal Speed Controller for Power Tools (SILICON CHIP, February 2009). On opening the kit however, I discovered that it is not suitable for a "shaded pole motor or an induction motor" which is probably what is used in my fan, so I will use it for my drill press.

The problem is, Airspeed (formerly based in St Leonards in Sydney) have gone out of business and I can't get any information on my fan. The motor

bears the following information:
Built under licence to GEC.
Type BS 2505.
V 220/240.
Phase 1 C/S50.
H.P. 1/4 Amps 2.3.
RPM 1425.
Insul class E.

My question is, is this a shaded-pole motor and therefore unsuitable to use with the universal 10A speed regulator I'm building? If so, can you tell me what sort of speed-control device I might build. (T. C., via email).

● Your fan motor is almost certainly a standard induction type. The clue is the speed – 1425 RPM. These large pedestal fans are used by the thousands right throughout industry and all over the world.

While there are induction motor speed controllers available, they would almost certainly be worth more than the fan itself. Nor do we have a suitable project which will do the job. Sorry.

Incidentally, your drill press is also likely to use an induction motor, especially if it has belt drive via stepped pulleys which can provide a range of fixed speeds.

RCD tester calibration

May I suggest a project to check the calibration of RCD testers. The cost of a calibration check by calibration facilities is not usually an economical proposition. Thousands of electricians need a reliable means of checking the accuracy of these testers. (N. P., Whangarei, NZ).

● We agree that the cost of calibrating of an RCD tester would probably be uneconomic, relative to the price of the tester itself. However, we would be very loath to design a suitable project and we would doubt its legality, even it were a relatively simple exercise.

Upgrading an analog insulation tester

I am looking at your Digital Insulation Meter from the June 2010 issue and note the comment that earlier "models" couldn't quite hack the voltage at lower load resistances. I actually built the Altronics 500V – 1000V Megohm Meter (dated 2004). What I like about this unit is the analog meter and for this type of measurement the moving pointer tells me more than the digital readout. Anyway, the Altronics unit also suffers from a weak output and I would like to upgrade it.

The simplest way to do this seems to be to just drop in the HV generator from your June 2010 design. Would that be sensible? The Altronics unit uses a very similar HV generator to the one you used in your October 2009 design. The issue I am uncertain about is the 10MΩ dropper from the HV supply in the Altronics and early SILICON CHIP designs is not present in the June 2010 unit. Instead, there is a 100nF capacitor to earth – presumably to limit the leakage current?

Would that work OK? I would like to keep the analog metering. (J. K., via email).

● You should be able to upgrade your 2004 Megohm Meter just by replacing its existing HV generator section with the one used in the June 2010 Insulation Meter, as you suggest. You should connect its output to the positive test terminal via the same 4.7kΩ 5W resistor we used in the June 2010 design, rather than via a 10MΩ resistor as in the original design.

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Please note, however, that if you give the generator the same three voltage ranges (1000V/500V/250V), you'll need to provide a third trimpot in the metering circuit to adjust the full-scale meter reading on the extra range.

Speed controller for variable solenoid drive

I was looking at your June 1997 Motor Speed Controller to pulse a vacuum/boost solenoid which in turn controls a butterfly fitted with

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Next Month In Silicon Chip: November 2011

Measuring Loudspeaker Performance With A DIY Microphone And Your PC's Sound Card

Following this month's article on measuring the performance of audio equipment using a sound card and an audio analyser software package, we follow with an article focussed on the measurement of loudspeakers. The method uses your PC's sound card, a DIY electret microphone and software from **www.fatpigdog.com**

Zener Diode Tester Adaptor For A DMM

Normal diodes are easy to test with the ohmmeter range on a typical digital multimeter but how do you test zener diodes which have have breakdown voltages up to 60V or more? This convenient battery-powered tester lets you check zener diodes rated from 2.2V up to 100V and you read the result from your DMM.

Low-Noise Preamplifier & 3-Input Selector

Intended for use with the Ultra-LD Mk.3 amplifier modules, this low-noise preamplifier will have remote control of volume with a motorised potentiometer and selection of up to three line-level inputs using the same remote control. The selector employs relay switching. The preamplifier is an improved version of the circuit used with the 20W Class-A stereo amplifier described in the August 2007 issue.

Unfortunately, the Geiger Counter which was to have been featured in this (October) issue has had to be postponed.

Note: these features are in preparation for publication and barring unforeseen circumstances, will be in the issue.

ON-SALE: Wednesday, 26th October 2011

a vacuum solenoid. It runs at 2kHz.

In order to work, it must have an adjustable frequency and from memory, down to approximately 20Hz. Can this circuit be modified to do this?

I have a device that used to do this function but it is kaput. It is used as a demonstration of an active exhaust at car shows. (K. D., via email).

● The Motor Speed Controller from June 1997 (Jaycar KC-5225) has now been superseded by the updated design in the June 2011 issue. This later version is similar to the earlier circuit and it now includes frequency adjustment over quite a wide range. If you require a lower frequency than it is presently capable of, you can increase the 100nF capacitor at pin 5 to a larger value, say 470nF.

Note that it is unusual for solenoids to be affected by the driving frequency, with these two provisos: (1) low frequencies (eg, 20Hz) could cause the solenoid to "chatter" on and off; and (2) if the frequency is too high, the solenoid impedance may mean that the available voltage drive may not be sufficient for effective drive.

It would be more usual to control the unit using a variable pulse width at a fixed frequency, to vary the solenoid opening. In other words, just use the controller without any modifications.

More volume wanted from sound card

I use headphones when talking on Skype but I find that the volume is too low from the PC sound card and I can't adjust it any higher. Have you ever published a project to amplify the sound from a PC sound card or could you suggest any other amplifying system that would suffice? (P. R., via email).

● As you suggest, one way to provide for more sound from your headphones is to add an amplifier between the computer sound output and the headphones. The Champ 0.5W amplifier (Silicon Chip, February 2004) would be suitable. Jaycar sell this as a kit (KC-5152) as does Altronics (K2115). This amplifier runs from a 4-12V supply and a 9V 200mA DC plugpack could power it.

Commercially-made headphone amplifiers are also available (eg, Jaycar AA0400). Another way would be to simply use more sensitive headphones. SC

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Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of Silicon Chip magazine.

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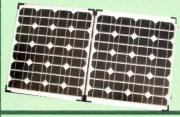

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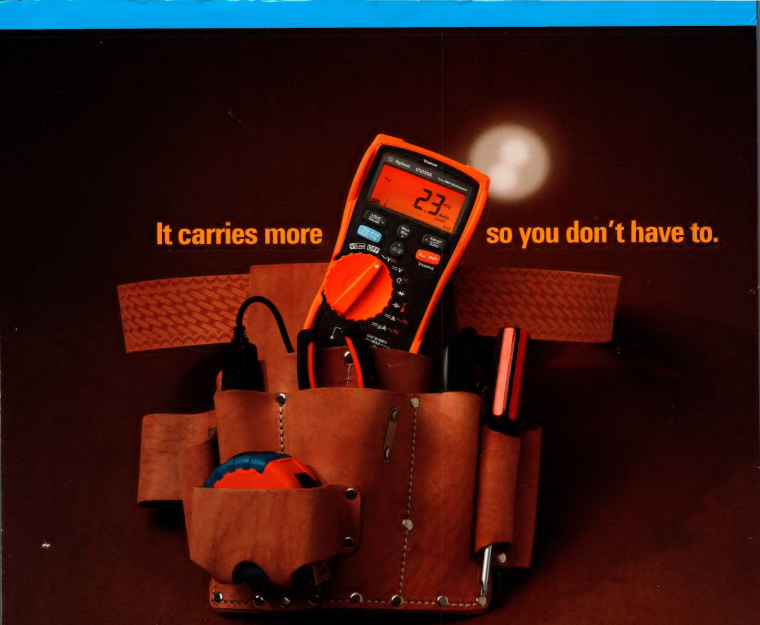

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